HANDBOOK

OF

THERMODYNAMIC TABLES AND DIAGRAMS

HANDBOOK OF THERMODYNAMIC TABLES AND DIAGRAMS

A SELECTION OF TABLES AND DIAGRAMS FROM

ENGINEERING THERMODYNAMICS

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PREFACE

WHILE the following tables and diagrams have been arranged primarily for use with the authors' Textbook of Engineering Thermodynamics it is thought that they will be of considerable value to all students of engineering as well as practicing engineers or others who may have occasion to undertake thermodynamic computations.

Most of the tables have been taken from Dr. Lucke's larger work on Engineering Thermodynamics, but some new ones have been added, among which are the very convenient four place hyperbolic and common logarithms, the plates for which were kindly loaned by Professor E. V. Huntington.

The authors desire to acknowledge their obligations to the various sources of information utilized in the preparation of the tables and diagrams. Special mention is due Professors Marks and Davis, for the use of material from their Steam Tables (Longmans, Green & Co.); to Mr. E. D. Thurston, Jr., whose invaluable help is gratefully acknowledged, and to Mr. T. M. Gunn for aid on part of the work.

C. E. L.
J. J. F.

JUNE, 1915.

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TABLE OF SYMBOLS

A = area in square feet.
a = area in square inches.
= coefficient of linear expansion.
Bé. = Baumé.
B.H.P. = brake horse-power; also boiler horse-power.
(bk. pr.) = back pressure in pounds per square inch.
C = Centigrade.
= coefficient for air flow.
= specific heat.
C_p = specific heat at constant pressure.
C_v = specific heat at constant volume.
C_l = clearance expressed in cubic feet.
c = clearance expressed as a fraction of the displacement.
= constant.
D = displacement in cubic feet.
(del. pr.) = delivery pressure in pounds per square inch.
E_v = volumetric efficiency (apparent).
F = constant in equation for pipe flow.
= Fahrenheit.
F_R = resistance factor, $F_R \times$ velocity head = loss due to resistances.
g = acceleration due to gravity, 32.2 (approx.) feet per second, per second.
H = as a subscript to denote high-pressure cylinder.
H.P. = horse-power.
h = height in inches.
K = coefficient of thermal conductivity
= constant.
K_e = engine constant $= \dfrac{\text{Lan}}{33,000}$ in expression for horse-power $= \dfrac{aS}{33,000}$.
L = as a subscript to denote low-pressure cylinder.
= latent heat.
= length of stroke in feet.
(L.P. Cap.) = low-pressure capacity.
l = length.
(M.E.P.) = mean effective pressure, pounds per square foot.
(m.b.p.) = mean back pressure in pounds per square inch.
(m.e.p.) = mean effective pressure in pounds per square inch.
(m.f.p.) = mean forward pressure in pounds per square inch.
N = revolutions per minute = R.P.M. or R.p.m.
P = pressure in pounds per square foot.
p = pressure in pounds per square inch.
Q = quantity of heat or energy in B.T.U. gained by a body passing from one state to another.
R = gas constant.
R_C = ratio of cylinder sizes in two-stage air compressor or compound engine.
R_p = ratio of delivery to supply pressure.

(rec. pr.) = receiver pressure in pounds per square inch.

S = piston speed.

= pounds of steam per pound of air in producer blast.

s = general exponent of V in expansion or compression of gases.

sp. gr. = specific gravity.

sp. ht. = specific heat.

(sup. pr.) = supply pressure, in pounds per square inch.

T = temperature, degrees absolute.

t = temperature in degrees scale.

$T\phi$ = temperature-entropy.

V = volume in cubic feet.

v = volume.

W = work in foot-pounds.

w = weight in pounds.

Wt. = weight.

x = constant in the expression for missing water.

= fraction of total weight liquified from the solid, or vaporized from the liquid = quality. If the vapor be superheated, the number of degrees of superheat also = quality.

y = ratio of the volume of receiver to that of the high-pressure cylinder of the compound engine.

Z = fraction of the stroke of the steam engine completed at cut-off.

z = ratio of R.P.M. to cycles per minute.

α, (alpha) = coefficient of cubical expansion.

α_v = constant in equation for variable specific heat at constant volume.

α_p = constant in equation for variable specific heat at constant pressure.

γ, (gamma) = special value for s for adiabatic expansion or compression =

$$\frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}.$$

δ, (delta) = density in pounds per cubic foot.

ζ, (zeta) = coefficient of friction.

Σ, (sigma) = summation.

$\Phi = \phi$, (phi) = entropy.

NOTE. A small letter when used as a subscript to a capital in general refers to a point on a diagram, e.g., P_a designates pressure at the point A. Two small letters used as subscripts together, refer in general to a quantity between two points, e.g., W_{ab} designates work done from point A to point B.

HANDBOOK OF
THERMODYNAMIC TABLES AND DIAGRAMS

PART I

INTRODUCTION

The province of Engineering Thermodynamics is to guide numerical thermal computations dealing with actual substances and apparatus in accordance with the laws of thermodynamic philosophy. In order to do this, numerical values for heat effects must be available for the various substances and materials used in engineering under the varying conditions of practice, and in such units as may readily be applied; these include especially that class of units known as physical constants which embrace, for example, such quantities as the coefficients of expansion, the specific heats, latent heats of fusion and vaporization, the ratio of the pressure-volume product to absolute temperature, the exponent "s" in adiabatic expansion of gases and vapors, and various other quantities. In addition to the physical constants which are necessary in the work of thermodynamic computation, the solution of numerical problems is greatly facilitated by the use of other correlated tables and diagrams many of which are given in the present book of tables, but to correctly use such aids there should be no ambiguity in regard to the units employed.

It should be noted that true pressures are always absolute, that is, measured above a perfect vacuum or counted from zero, while most pressure gages and other devices for measuring pressure, such as indicators, give results measured above or below atmospheric pressure. In all problems involving work of gases and vapors, the absolute values of the pressures must be used; hence, if a gage or indicator measurement is being considered, the pressure of the atmosphere found by means of the barometer must be added to the pressure above atmosphere in order to obtain the absolute or true pressures. When the pressures are below atmosphere the combination with the barometric reading will depend on the record; if the record be taken by an indicator it will be in pounds per square inch below atmosphere and must be subtracted from the barometric equivalent in the same units to give the absolute pressure in pounds per square inch. When, however, a vacuum gage reads in inches of mercury below atmosphere, as such gages do, the difference between its reading and the barometric gives the absolute pressure in inches of mercury directly, which can be converted to the desired units by the proper factors.

In general, steam pressures are most commonly stated in pounds per square

inch and are designated as either gage or absolute. Pressures of compressed air are commonly expressed in the same units as steam, either gage or absolute, though sometimes in atmospheres. Steam pressures below atmosphere are conveniently stated as a vacuum of so many inches of mercury, or they may be given as a pressure of so many inches of mercury absolute or so many pounds per square inch absolute. The pressures of gases stored in tanks under high pressure are frequently recorded in atmospheres due to the convenience of computation of quantities on this basis. Pressures of air obtained by blowers or fans are sometimes given in ounces per square inch above atmosphere, but such pressures, and also differences of pressure of air due to chimney draught, or forced draught, and the pressure of illuminating gas in city mains are commonly stated in inches of water. In many cases the data are given in other units which must be converted by the use of tables, diagrams or otherwise, before the results can be properly interpreted or intelligently compared.

Time is an important item in all engineering work and none the less so in computations, so that convenient tables and diagrams are most essential to the solution of such problems. In some cases graphic methods are the only means of solution; in others the problems may be solved directly without the use of formulas, and in still others certain steps may be shortened. In many engineering calculations no one is justified in using a complicated mathematical formula; if too much time be required to make the calculation in commercial work it will not be made, therefore indirect and often approximate methods are substituted. In such cases the nearest tabular or chart value must be used, and generally the result will be as accurate as the work requires.

In the following tables and charts the accompanying title usually indicates the character of each table or diagram and little explanation is necessary. The tables for dry saturated steam, and properties of superheated steam are those of Marks and Davis. From the investigation made by Marks and Davis it is believed that the properties of saturated steam given in the tables are correct to within one-tenth of 1 per cent. for pressures within the range of ordinary engineering practice.

The unit of heat and of energy in these tables is a mean B.T.U. or $\frac{1}{180}$ of the heat required to raise 1 lb. of water from 32° to 212°.

The value of one mean B.T.U. as used in these tables is equivalent to 777.52 ft.-lbs. when the gravitational constant is 980.665 cm. sec.^{2} which corresponds to 32.174 lbs. and is the value for latitude between 45° and 46°. For many years it has been most common to use in engineering calculations, the round number 778; for most problems this round number is still the best available figure, but where special accuracy is needed it is likely that no closer value can be relied upon than anything between 777.5 and 777.6 for the above latitude.

Investigations, particularly by Knobloch and Jacob, by Thomas and by Henning, show that the specific heat of superheated steam is not constant, but is a function of both pressure and temperature. The curves derived by Marks

and Davis for specific heat of superheated steam from a critical examination of the material available are given in the charts.

As the method used in the derivation of the steam tables is so rational and scientific it has been adopted for a new determination of the relations between pressure and temperature for ammonia and carbon dioxide, both important substances in refrigeration. The tables of properties for ammonia and carbon dioxide thus determined give the final values of total heat, heat of liquid, latent heat, specific volume and density of dry saturated vapor based upon large scale plottings, without equations beyond those for the pressure-temperature relations for saturated vapor. The results are believed to be as reliable as it is possible to have them without more experimental data.

The Mollier total heat-entropy diagram for steam makes possible the solution of many problems involving both saturated and superheated steam. Since this chart is so convenient for turbine work, a scale of corresponding steam-jet velocities has been added to the diagram. Temperature-entropy and Mollier diagrams have also been plotted for ammonia and carbon dioxide, from which the work may readily be obtained.

The analyses of gases, oils, coals, and other fuels given in the tables will be found of great value to the engineer. These values have been selected from the most reliable sources available, but it is worth noting that in the analyses of oil gas there is quite a probability of uncertainty in the hydrocarbons reported. There is also some doubt, at least for gases, in the values given in the table of ignition temperatures (Table XXXIII). The ignition of a combustible is not by any means a simple operation especially when the fuel is in the form of an explosive gas mixture. With the latter the ignition temperature, true or apparent, is different for different proportions of air and fuel, and likewise still different when neutrals are present. For this reason there may be various ignition temperatures for the same substance; this is known to be true for gases. The values given in the tables therefore must be considered as ignition temperatures not *the* ignition temperature.

Attention is called to the general coal tables (No. LV and LVI), the first of which gives the proximate and ultimate analysis of upward of 200 different coals covering the range from peat to anthracite. For each fuel the calorific power is also given. Table LVI constitutes a new table derived from No. LV in which the chemical and thermal properties have been re-determined as ash and moisture free. In this table the calorific power of the combustible is reported, total and as divided between the fixed carbon and the volatile parts, and finally the calorific power of the volatile itself per pound is found. The product of the fractional weight of the fixed carbon and 14,544, its known calorific power, gives the heat due to the combustion of the fixed carbon part of the combustible, and this subtracted from the B.T.U. per pound of combustible gives the heat per pound of combustible derived from its volatile. The heat per pound of combustible derived from its volatile only, when divided by the fractional weight of volatile in the combustible gives the B.T.U. per pound of

volatile itself. Thus the character of heating power of the volatile of the coals furnishes a new basis of classification with direct reference to availability as fuels, and makes possible the calculation of the calorific power of a coal with fair accuracy, from its easily found proximate analysis.

In general, the charts presented in this book have been drawn to a sufficiently large scale to permit direct solution of most problems with a reasonable degree of accuracy. However, in certain cases it is advisable to plot new diagrams to a larger scale in order to ensure still greater accuracy of result.

Where it has been deemed advisable the derivation and use of the chart has been given in the text; but where this description would involve a lengthy explanation it has been omitted; in such cases the reader is referred to the authors' Textbook of Engineering Thermodynamics for a complete discussion of the construction of the diagrams. It will be understood that the numbers of equations given in the descriptive matter refer to the textbook quoted. In some of the charts the curves have been plotted from tabular values derived from experiment or calculated from formulas; under these conditions the method of derivation is obvious and will not be referred to in the text.

Table I

CONVERSION TABLE OF UNITS OF DISTANCE

Meters.[1]	Kilometers.	Inches.	Feet.	Statute Miles.	Nautical Miles.
1	0.001	39.37	3.28083	0.000621370	0.000539587
1000	1	39370.1	3280.83	0.62137	0.539587
0.0254	0.0000254	1	0.083333	0.0000157828	0 0000137055
0.304801	0.0003048	12	1	0.000189394	0.000164466
1609.35	1.60935	63360	5280	1.	0.868382
1853.27	1.85327	72963.2	6080.27	1.15157	1.

[1] In accordance with U. S. Standards (see Smithsonian Tables).

Table II

CONVERSION TABLE OF UNITS OF SURFACE

Sq. Meters.	Sq. Inches.	Sq. Feet.	Sq. Yards.	Acres.	Sq. Miles.
1	1550.00	10.76387	1.19599	.000247	
.000645	1	.00694			
.0929	144	1	.111		
.8361	1296	9	1	.000206	
4046.87	....	43560	4840	1	.001562
2589999	....	27878400	3097600	640	1

Table III

CONVERSION TABLE OF UNITS OF VOLUME

Cu. Meters.	Cu. Inches.	Cu. Feet.	Cu. Yards.	Litres (1000 Cu. Cm.)	Gallons (U.S.)
1	61023.4	35.3145	1.3079	1000	264.170
....	1	.000578	....	.016387	.00433
.028317	1728	1	.03704	28.317	7.4805
.76456	46656	27	1	....	201.974
.001	61.023	.035314	.001308	1	.26417
.003785	231	.13368	.004951	3.7854	1

Table IV

CONVERSION TABLE OF UNITS OF WEIGHT AND FORCE

Kilogrammes.	Metric Tons.	Pounds.	U. S. or Short Tons.	British or Long Tons.
1.	0.001	2.20462	0.00110231	0.000984205
1000.	1.	2204.62	1.10231	0.984205
0.453593	0.000453593	1.	0.0005	0.000446429
907.186	0.907186	2000.	1.	0.892957
1016.05	1.01605	2240.	1.12000	1.

TABLE V

CONVERSION TABLE OF UNITS OF PRESSURE

	Pounds per Square Foot.	Pounds per Square Inch.	Inches of Mercury at 32° F.	Atmospheres (Standard at Sea Level).
One lb. per sq. ft.	1	0.006944	0.014139	0.0004724
One lb. per sq. in.	144.	1.	2.03594	0.06802
One ounce per sq. in.	9.	0.0625	0.127246	0.004252
One atmosphere (standard at sea level)	2116.1	14.696	29.924	1.
One kilogramme per square meter	20.4817	0.142234	0.289579	0.009678
One gramme per square millimeter	204.817	1.42234	2.89579	0.09678
One kilogramme per square centimeter	2048.17	14.2234	28.9579	0.9678
FLUID PRESSURES				
One ft. of water at 39.1° F. (max. dens.)	62.425	0.43350	0.88225	0.029492
One ft. of water at 62° F.	62.355	0.43302	0.88080	0.029460
One in. of water at 62° F.	5.196	0.036085	0.07340	0.002455
One in. of mercury at 32° F. (standard) [1]	70.7290	0.491174	1.	0.033416
One centimeter of mercury at 0° C.	27.8461	0.193376	0.393701	0.013158
One ft. of air at 32° F., one atmos. press.	0.08071	0.0005604	0.0011412	0.00003813
One ft. of air, 62° F.	0.07607	0.0005282	0.0010755	0.00003594

[1] PRESSURES MEASURED BY THE MERCURY COLUMN. For temperatures other than 32° F., the density of mercury, pounds per cubic inch, and hence the pressure, pounds per square inch, due to a column of mercury 1 inch high, is given with sufficient accuracy by the following formula:

$$p = 0.4912 - (t - 32) \times 0.0001.$$

The mercurial barometer is commonly made with a brass scale which has its standard or correct length at 62° F, and a linear coefficient of expansion of about 0.000001 for each degree Fahrenheit. Hence, to correct the standard mercury at 32° F., the corrected reading will be

$$H_{32} = H_t - H_t \times \frac{t - 28.6}{11000}$$

where H_t is the observed height at a temperature of $t°$ F.

TABLE VI

CONVERSION TABLE OF UNITS OF WORK

Kilogrammeters.	Foot-pounds.	Foot Tons (Short Tons).	Foot Tons (Long Tons).
1.	7.23300	0.00361650	0.00322902
0.138255	1.	0.000500	0.000446429
276.510	2000.	1.	0.892857
309.691	2240.	1.12000	1.

TABLE VII
CONVERSION TABLE OF UNITS OF POWER

Foot-pounds per Second.	Foot-pounds per Minute.	Horse-power.	Cheval-Vapeur.	Kilogrammeters per Minute.
1.	60.	0.00181818	0.00184340	8.29531
0.0166667	1.	0.000030303	0.0000307241	0.138252
550.000	33000.	1.	1.01387	4562.42
542.475	32548.5	0.986319	1.	4500.00
0.120550	7.23327	0.000219182	0.000222222	1.

TABLE VIII
UNITS OF VELOCITY

	Feet per Minute.	Feet per Second.
One foot per second	60.	1.
One foot per minute	1.	0.016667
One statute mile per hour	88.	1.4667
One nautical mile per hour = 1 knot.	101.338	1.6890
One kilometer per hour	54.6806	0.911344
One meter per minute	3.28084	0.054581
One centimeter per second	2.00848	0.032808

TABLE IX
HEAT AND POWER CONVERSION TABLE

Calorie Kilo °C.	B.T.U. Lb. °F.	Lb. ° C.	Kilo °F.	Calorie per Lb.	B.T.U. per Lb.	B.T.U. per Kilo.	Calorie per Kilo.
1.	3.9683	2.2046	1.8	1.	3.9683	8.7483	2.2046
.252	1.	.5556	.4536	.252	1.	2.2046	.5807
.4536	1.8	1.	.8165	.1143	.4536	1	.252
.5556	2.2046	1.2261	1.	.4536	1.8	3.9683	1.

Calorie per Cu. Ft.	B.T.U. per Cu. Ft.	Calorie per Liter.	B.T.U. per Liter.
1.	3.9683	.0353	.1402
.252	1.	.0089	.0353
28.317	112.37	1.	3.9683
7.136	28.317	.252	1.

Ft.-Lb.	B.T.U.	Calorie.	Cent. Heat Unit, At.	H.P. Sec.	H.P. Min.	H.P. Hour.
1	1.286×10^{-3}	$.324\times10^{-3}$	$.18\times10^{-3}$	1.818×10^{-3}	$.303\times10^{-4}$	5.05×10^{-7}
777.5	1	.252	.5556	1.414	2.356×10^{-2}	3.927×10^{-4}
3086	3.9683	1	2.2046	5.61	9.35×10^{-2}	1.558×10^{-3}
1399.5	1.8	.4536	1	2.545	4.24×10^{-2}	$.707\times10^{-3}$
550	.7074	.1783	.3931	1	1.67×10^{-2}	2.777×10^{-4}
3.3×10^{4}	42.44	10.695	23.578	60	1	1.67×10^{-2}
1.98×10^{6}	2545	641	1.413×10^{3}	3600	60	1

Table X

TABLE OF BAROMETRIC HEIGHTS, ALTITUDES, AND PRESSURES

(Adapted from Smithsonian Tables)

Barometric heights are given in inches and millimeters of mercury at its standard density (32° F.).

Altitudes are heights above mean sea level in feet, at which this barometric height is standard. (See Smithsonian Tables for corrections for latitude and temperature.)

Pressures given are the equivalent of the barometric height in lbs. per sq. in. and per sq. ft.

Standard Barometer.		Altitude, Feet above Sea Level.	Pressure, Pounds per	
Inches.	Centimeters.		Square Inch.	Square Foot.
17.0	43.18	15379	8.350	1202.3
17.2	43.69	15061	8.448	1216.6
17.4	44.20	14746	8.546	1230.7
17.6	44.70	14435	8.645	1244.8
17.8	45.21	14128	8.742	1259.0
18.0	45.72	13824	8.840	1273.2
18.2	46.23	13523	8.940	1287.3
18.4	46.73	13226	9.038	1301.4
18.6	47.24	12931	9.136	1315.6
18.8	47.75	12640	9.234	1329.7
19.0	48.26	12352	9.332	1343.8
19.2	48.77	12068	9.430	1357.9
19.4	49.28	11786	9.529	1372.1
19.6	49.78	11507	9.627	1386.3
19.8	50.29	11230	9.726	1400.4
20.0	50.80	10957	9.825	1414.6
20.2	51.31	10686	9.922	1428.7
20.4	51.82	10418	10.020	1442.9
20.6	52.32	10153	10.118	1457.0
20.8	52.83	9890	10.217	1471.2
21.0	53.34	9629	10.315	1485.3
21.2	53.85	9372	10.414	1499.4
21.4	54.36	9116	10.511	1513.6
21.6	54.87	8863	10.609	1527.7
21.8	55.37	8612	10.707	1541.8
22.0	55.88	8364	10.806	1556.0
22.2	56.39	8118	10.904	1570.1
22.4	56.90	7874	11.002	1584.3
22.6	57.40	7632	11.100	1598.4
22.8	57.91	7392	11.198	1612.6
23.0	58.42	7155	11.297	1626.7
23.2	58.92	6919	11.395	1640.8
23.4	59.44	6686	11.493	1655.0
23.6	59.95	6454	11.592	1669.3
23.8	60.45	6225	11.690	1683.3
24.0	60.96	5997	11.788	1697.4
24.2	61.47	5771	11.886	1711.6
24.4	61.98	5547	11.984	1725.7
24.6	62.48	5325	12.083	1739.9
24.8	62.99	5105	12.182	1754.0
25.0	63.50	4886	12.280	1768.2
25.2	64.01	4670	12.377	1782.3
25.4	64.52	4455	12.475	1796.5
25.6	65.02	4241	12.573	1810.7
25.8	65.53	4030	12.671	1824.8

TABLE X—*Continued*

Standard Barometer.		Altitude, Feet above Sea Level.	Pressure, Pounds per	
Inches.	Centimeters.		Square Inch.	Square Foot.
26.0	65.04	3820	12.770	1838.9
26.1	66.30	3715	12.819	1846.0
26.2	66.55	3611	12.868	1853.1
26.3	66.80	3508	12.918	1860.2
26.4	67.06	3404	12.967	1867.3
26.5	67.31	3301	13.016	1874.3
26.6	67.57	3199	13.065	1881.4
26.7	67.82	3097	13.113	1888.5
26.8	68.08	2995	13 163	1895.5
26.9	68.33	2894	13.212	1902.6
27.0	68.58	2793	13.261	1909.7
27.1	68.84	2692	13.310	1916.7
27.2	69.09	2592	13.359	1923.8
27.3	69.34	2493	13.408	1930.9
27.4	69.60	2393	13.457	1938.0
27.5	69.85	2294	13.507	1945.1
27.6	70.10	2195	13.556	1952.1
27.7	70.35	2097	13.605	1959.2
27.8	70.61	1999	13.654	1966.3
27.9	70.87	1901	13.704	1973.3
28.0	71.12	1804	13.753	1980.4
28.1	71.38	1707	13.802	1987.5
28.2	71.63	1610	13.850	1994.5
28.3	71.88	1514	13.899	2001.6
28.4	72.14	1418	13.948	2008.7
28.5	72.39	1322	13.998	2015.7
28.6	72.64	1227	14.047	2022.8
28.7	72.90	1132	14.096	2030.0
28.8	73.15	1038	14.145	2037.0
28.9	73.40	943	14.194	2044.1
29.0	73.66	849	14.243	2051.2
29.1	73.92	756	14.293	2058.2
29.2	74.16	663	14.342	2065.3
29.3	74.42	570	14.392	2072.4
29.4	74.68	477	14.441	2079.4
29.5	74.94	384	14.490	2086.5
29.6	75.18	292	14.539	2093.6
29.7	75.44	261	14.588	2100.7
29.8	75.69	109	14.637	2107.7
29.9	75.95	+18	14.686	2114.7
29.92	76.00	0	14.696	2116.1
30.0	76.20	− 73	14.734	2121.7
30.1	76.46	−163	14.783	2128.8
30.2	76.71	−253	14.833	2135.9
30.3	76.96	−343	14.882	2143.0
30.4	77.22	−433	14.931	2150.1
30.5	77.47	−522	14.980	2157.2
30.6	77.72	−611	15.030	2164.2
30.7	77.98	−700	15.078	2171.3
30.8	78.23	−788	15.127	2178.4
30.9	78.48	−877	15.176	2185.5
31.0	78.74	−965	15.226	2192.6

Table XI

CONVERSION TABLE INCHES OF MERCURY TO POUNDS PER SQUARE INCH

(Calculated for a Temperature of 32° F.)

To correct for other temperatures see footnote Table V

In. Hg	0	1	2	3	4	5	6	7	8	9
0	....	0.0491	0.0982	0.1473	0.1964	0.2456	0.2947	0.3438	0.3929	0.4421
1	0.4912	0.5403	0.5894	0.6385	0.6877	0.7368	0.7859	0.8350	0.8841	0.9333
2	0.9824	1.0315	1.0806	1.1297	1.1788	1.2280	1.2771	1.3262	1.3753	1.4244
3	1.4736	1.5227	1.5718	1.6209	1.6701	1.7192	1.7683	1.8174	1.8665	1.9157
4	1.9648	2.0139	2.0630	2.1121	2.1613	2.2104	2.2595	2.3086	2.3577	2.4069
5	2.4560	2.5051	2.5542	2.6033	2.6525	2.7016	2.7507	2.7998	2.8489	2.8981
6	2.9472	2.9963	3.0454	3.0945	3.1437	3.1928	3.2419	3.2910	3.3401	3.3893
7	3.4384	3.4875	3.5366	3.5857	3.6349	3.6840	3.7331	3.7822	3.8313	3.8809
8	3.9296	3.9787	4.0278	4.0769	4.1261	4.1752	4.2243	4.2734	4.3225	4.3717
9	4.4208	4.4699	4.5190	4.5681	4.6173	4.6664	4.7155	4.7646	4.8137	4.8629
10	4.912	4.9611	5.0102	5.0593	5.1085	5.1576	5.2067	5.2558	5.3049	5.3541
11	5.4032	5.4523	5.5014	5.5505	5.5997	5.6488	5.6979	5.7470	5.7961	5.8453
12	5.894	5.9435	5.9926	6.0417	6.0909	6.1400	6.1891	6.2382	6.2873	6.3365
13	6.3856	6.4347	6.4838	6.5329	6.5821	6.6312	6.6803	6.7294	6.7785	6.8277
14	6.8768	6.9259	6.9750	7.0241	7.0733	7.1224	7.1715	7.2206	7.2697	7.3189
15	7.3680	7.4171	7.4662	7.5153	7.5645	7.6136	7.6627	7.7118	7.7609	7.8101
16	7.8592	7.9083	7.9574	8.0065	8.0557	8.1048	8.1539	8.2030	8.2521	8.3013
17	8.3504	8.3995	8.4486	8.4977	8.5469	8.5960	8.6451	8.6942	8.7433	8.7925
18	8.8416	8.8907	8.9398	8.9889	9.0381	9.0872	9.1363	9.1854	9.2345	9.2837
19	9.3328	9.3819	9.4310	9.4801	9.5293	9.5784	9.6275	9.6766	9.7257	9.7788
20	9.8240	9.8731	9.9222	9.9713	10.020	10.069	10.118	10.168	10.217	10.266
21	10.315	10.364	10.413	10.462	10.511	10.561	10.610	10.659	10.708	10.757
22	10.806	10.855	10.904	10.953	11.003	11.052	11.101	11.150	11.199	11.248
23	11.297	11.346	11.396	11.445	11.494	11.543	11.592	11.641	11.690	11.739
24	11.789	11.838	11.887	11.936	11.985	12.034	12.083	12.132	12.181	12.231
25	12.280	12.329	12.378	12.427	12.476	12.525	12.574	12.624	12.673	12.722
26	12.771	12.820	12.869	12.918	12.967	13.017	13.066	13.115	13.164	13.213
27	13.262	13.311	13.360	13.409	13.459	13.508	13.557	13.606	13.655	13.704
28	13.753	13.802	13.852	13.901	13.950	13.999	14.048	14.097	14.146	14.195
29	14.245	14.294	14.343	14.392	14.441	14.490	14.539	14.588	14.637	14.689
30	14.736	14.785	14.834	14.883	14.932	14.981	15.030	15.080	15.129	15.178
31	15.227	15.276	15.325	15.374	15.423	15.473	15.530	15.571	15.620	15.669

Table XII

PISTON POSITIONS FOR ANY CRANK ANGLE

From Beginning of Stroke Away from Crank Shaft to Find Piston Position from Dead-Center Multiply Stroke by Tabular Quantity

Crank Angle.	$\frac{l}{r}=4$	$\frac{l}{r}=4.5$	$\frac{l}{r}=5$	$\frac{l}{r}=5.5$	$\frac{l}{r}=6$	$\frac{l}{r}=7$	$\frac{l}{r}=8$	$\frac{l}{r}=9$
5	.0014	.0015	.0015	.0016	.0016	.0016	.0017	.0019
10	.0057	.0059	.0061	.0062	.0063	.0065	.0067	.0076
15	.0128	.0133	.0137	.0140	.0142	.0146	.0149	.0170
20	.0228	.0237	.0243	.0248	.0253	.0260	.0265	.0302
25	.0357	.0368	.0379	.0388	.0394	.0405	.0413	.0468
30	.0513	.0531	.0545	.0556	.0565	.0581	.0592	.0670
35	.0698	.0721	.0740	.0754	.0767	.0787	.0801	.0904
40	.0910	.0939	.0962	.0981	.0997	.1022	.1041	.1170
45	.1152	.1187	.1215	.1237	.1256	.1286	.1308	.1468
50	.1416	.1458	.1491	.1518	.1541	.1576	.1607	.1786
55	.1713	.1759	.1828	.1827	.1853	.1892	.1922	.2132
60	.2026	.2079	.2122	.2157	.2186	.2231	.2295	.2500
65	.2374	.2431	.2477	.2514	.2545	.2594	.2630	.2886
70	.2730	.2794	.2844	.2885	.2929	.2973	.3013	.3290
75	.3123	.3187	.3239	.3282	.3317	.3372	.3414	.3705
80	.3516	.3586	.3642	.3687	.3725	.3784	.3828	.4132
85	.3944	.4013	.4068	.4113	.4151	.4210	.4254	.4564
90	.4365	.4437	.4495	.4547	.4580	.4641	.4686	.5000
95	.4816	.4885	.4940	.4985	.5022	.5081	.5126	.5436
100	.5253	.5323	.5378	.5424	.5461	.5520	.5564	.5868
105	.5711	.5775	.5828	.5870	.5905	.5961	.6002	.6294
110	.6150	.6214	.6265	.6306	.6340	.6393	.6530	.6710
115	.6600	.6657	.6703	.6740	.6771	.6820	.6856	.7113
120	.7026	.7080	.7122	.7157	.7186	.7231	.7265	.7500
125	.7449	.7495	.7533	.7563	.7588	.7628	.7658	.7868
130	.7844	.7885	.7920	.7947	.7969	.8004	.8030	.8214
135	.8223	.8258	.8286	.8308	.8327	.8357	.8379	.8535
140	.8570	.8600	.8623	.8642	.8658	.8682	.8703	.8830
145	.8889	.8913	.8931	.8946	.8958	.8978	.8993	.9096
150	.9173	.9191	.9204	.9216	.9226	.9241	.9252	.9330
155	.9420	.9432	.9452	.9451	.9457	.9468	.9476	.9531
160	.9625	.9633	.9640	.9645	.9650	.9656	.9661	.9698
165	.9787	.9792	.9796	.9799	.9802	.9805	.9809	.9829
170	.9905	.9908	.9909	.9911	.9912	.9913	.9915	.9924
175	.9976	.9977	.9977	.9977	.9978	.9978	.9979	.9981
180	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

l = length of connecting rod.
r = radius of crank.

Table XIII

HORSE-POWER PER POUND MEAN EFFECTIVE PRESSURE

$$\text{VALUE OF } K_e = \frac{aS}{33000} = \frac{\text{Area } \square'' \times \text{speed in ft.p.m.}}{33000}$$

Diameter of Cylinder, Inches.	Speed of Piston in Feet per Minute.								
	100	200	300	400	500	600	700	800	900
4	0.0381	0.0762	0.1142	0.1523	0.1904	0.2285	0.2666	0.3046	0.3427
4½	0.0482	0.0964	0.1446	0.1928	0.2410	0.2892	0.3374	0.3856	0.4338
5	0.0592	0.1190	0.1785	0.2380	0.2975	0.3570	0.4165	0.4760	0.5355
5½	0.0720	0.1440	0.2160	0.2880	0.3600	0.4320	0.5040	0.5760	0.6480
6	0.0857	0.1714	0.2570	0.3427	0.4284	0.5141	0.5998	0.6854	0.7711
6½	0.1006	0.2011	0.3017	0.4022	0.5028	0.6033	0.7039	0.8044	0.9050
7	0.1166	0.2332	0.3499	0.4665	0.5831	0.6997	0.8163	0.9330	1.0490
7½	0.1339	0.2678	0.4016	0.5355	0.6694	0.8033	0.9371	1.0710	1.2049
8	0.1523	0.3046	0.4570	0.6093	0.7616	0.9139	1.0662	1.2186	1.3709
8½	0.1720	0.2439	0.5159	0.6878	0.8598	1.0317	1.2037	1.3756	1.5476
9	0.1928	0.3856	0.5783	0.7711	0.9639	1.1567	1.3495	1.5422	1.7350
9½	0.2148	0.4296	0.6444	0.8592	1.0740	1.2888	1.5036	1.7184	1.9532
10	0.2380	0.4760	0.7140	0.9520	1.1900	1.4280	1.6660	1.9040	2.1420
11	0.2880	0.5760	0.8639	1.1519	1.4399	1.7279	2.0159	2.3038	2.5818
12	0.3427	0.6854	1.0282	1.3709	1.7136	2.0563	2.3990	2.7418	3.0845
13	0.4022	0.8044	1.2067	1.6089	2.0111	2.4133	2.8155	3.2178	3.6200
14	0.4665	0.9330	1.3994	1.8659	2.3324	2.7989	3.2654	3.7318	4.1983
15	0.5355	1.0710	1.6065	2.1420	2.6775	3.2130	3.7485	4.2840	4.8195
16	0.6093	1.2186	1.8278	2.4371	3.0464	3.6557	4.2650	4.8742	5.4835
17	0.6878	1.2756	1.9635	2.6513	3.3391	4.0269	4.6147	5.4026	6.1904
18	0.7711	1.5422	2.3134	3.0845	3.8556	4.6267	5.3987	6.1690	6.4901
19	0.8592	1.7184	2.5775	3.4367	4.2858	5.1551	6.0143	6.8734	7.7326
20	0.9520	1.9040	2.8560	3.8080	4.7600	5.7120	6.6640	7.6160	8.5680
21	1.0496	2.0992	3.1488	4.1983	5.2475	6.2975	7.3471	8.3966	9.4462
22	1.1519	2.3038	3.4558	4.6077	5.7596	6.9115	8.0643	9.2154	10.367
23	1.2590	2.5180	3.7771	5.0361	6.2951	7.5541	8.8131	10.072	11.331
24	1.3709	2.7418	4.1126	5.4835	6.8544	8.2253	9.5962	10.967	12.338
25	1.4875	2.9750	4.4625	5.9500	7.4375	8.9250	10.413	11.900	13.388
26	1.6089	3.2178	4.8266	6.4355	8.0444	9.6534	11.262	12.871	14.480
27	1.7350	3.4700	5.2051	6.9401	8.6751	10.410	12.145	13.880	15.615
28	1.8659	3.7318	5.5978	7.4637	9.3296	11.196	13.061	14.927	16.793
29	2.0016	4.0032	6.0047	8.0063	10.008	12.009	14.011	16.013	18.014
30	2.1420	4.2840	6.4260	8.5680	10.710	12.852	14.994	17.136	19.278
31	2.2872	4.5744	6.8615	9.1487	11.436	13.723	16.010	18.287	20.585
32	2.4371	4.8742	7.3114	9.7485	12.186	14.623	17.060	19.497	21.934
33	2.5918	5.1836	7.7755	10.367	12.959	15.551	18.143	20.735	23.326
34	2.7513	5.5026	8.2538	11.005	13.756	16.508	19.259	22.010	24.762
35	2.9155	5.8310	8.7465	11.662	14.578	17.493	20.409	23.224	26.240
36	3.0845	6.1690	9.2534	12.338	15.422	18.507	21.591	24.676	27.760
37	3.2582	6.5164	9.7747	13.033	16.291	19.549	22.808	26.066	29.324
38	3.4367	6.8734	10.310	13.747	17.184	20.620	24.057	27.494	30.930
39	3.6200	7.2400	10.860	14.480	18.100	21.720	25.340	28.960	32.580
40	3.8080	7.6160	11.424	15.232	19.040	22.848	26.656	30.464	34.272

TABLE XIV

CONSTANTS FOR THE CURVE $PV^s = K$

(Modified from Klein and Heck)

The tabular value under "Exp." is equal to $\left(\frac{V_1}{V_2}\right)^s$ corresponding to the given ratio of the assumed increasing volume V_2 to initial volume V_1; the tabular value under "Comp." is equal to $\left(\frac{P_2}{P_1}\right)^{\frac{1}{s}}$ corresponding to the given ratio of the assumed increasing pressure P_1 to the initial pressure P_2.

Ratio	Logarithmic expansion $s = 1$	Constant steam weight		Adiabatic of saturated steam for $x =$ 0.7	0.9	1.0	Compression curve with steam jacketed cylinder		Adiabatic of superheated steam		Adiabatic of air	
		$s = 1.065$		1.105	1.125	1.135	$s = 1.250$		$s = 1.33$		$s = 1.406$	
		Exp.	Comp.	Exp.	Exp.	Exp.	Exp.	Comp.	Exp.	Comp.	Exp.	Comp.
1.25	0.8000	0.7885	0.8110	0.7815	0.7780	0.7763	0.7569	0.8365	0.7427	0.8459	0.7307	0.8533
1.50	0.6667	0.6493	0.6843	0.6389	0.6337	0.6312	0.6024	0.7230	0.5824	0.7378	0.5655	0.7495
1.75	0.5714	0.5510	0.5913	0.5388	0.5328	0.5299	0.4968	0.6391	0.4742	0.6572	0.4553	0.6716
2.00	0.5000	0.4780	0.5216	0.4649	0.4585	0.4553	0.4265	0.5743	0.3969	0.5946	0.3774	0.6108
2.25	0.4444	0.4216	0.4670	0.4082	0.4016	0.3984	0.3629	0.5226	0.3393	0.5443	0.3198	0.5617
2.50	0.4000	0.3769	0.4230	0.3633	0.3567	0.3535	0.3121	0.4804	0.2947	0.5030	0.2757	0.5212
2.75	0.3636	0.3405	0.3868	0.3270	0.3204	0.3172	0.2824	0.4451	0.2596	0.4683	0.2412	0.4870
3.00	0.3333	0.3104	0.3565	0.2970	0.2906	0.2874	0.2533	0.4152	0.2311	0.4387	0.2134	0.4578
3.50	0.2857	0.2634	0.3084	0.2505	0.2443	0.2413	0.2089	0.3671	0.1882	0.3908	0.1718	0.4102
4.00	0.2500	0.2285	0.2721	0.2161	0.2102	0.2073	0.1768	0.3299	0.1575	0.3536	0.1424	0.3731
4.50	0.2222	0.2015	0.2436	0.1898	0.1841	0.1814	0.1526	0.3002	0.1346	0.3237	0.1207	0.3431
5.0	0.2000	0.1801	0.2206	0.1689	0.1636	0.1609	0.1337	0.2760	0.1170	0.2991	0.1041	0.3183
6.0	0.1667	0.1483	0.1859	0.1381	0.1332	0.1309	0.1065	0.2385	0.0917	0.2609	0.0805	0.2796
7.0	0.1429	0.1259	0.1609	0.1165	0.1120	0.1099	0.0878	0.2158	0.0747	0.2324	0.0448	0.2506
8.0	0.1250	0.1092	0.1419	0.1005	0.0964	0.0944	0.0743	0.1895	0.0625	0.2102	0.0537	0.2274
9.0	0.1111	0.0963	0.1271	0.0882	0.0844	0.0826	0.0642	0.1724	0.0534	0.1925	0.0455	0.2096
10.0	0.1000	0.0861	0.1151	0.0785	0.0750	0.0733	0.0562	0.1585	0.0464	0.1778	0.0393	0.1944
12.0	0.0833	0.0709	0.0970	0.0642	0.0611	0.0596	0.0450	0.1369	0.0364	0.1551	0.0304	0.1708
14.0	0.0714	0.0602	0.0839	0.0541	0.0514	0.0500	0.0369	0.1210	0.0296	0.1382	0.0245	0.1531
16.0	0.0625	0.0522	0.0740	0.0467	0.0442	0.0430	0.0313	0.1088	0.0248	0.1250	0.0203	0.1392
18.0	0.0556	0.0460	0.0663	0.0410	0.0387	0.0376	0.0270	0.0991	0.0212	0.1144	0.0172	0.1280
20.0	0.0500	0.0412	0.0600	0.0365	0.0345	0.0334	0.0236	0.0910	0.0184	0.1057	0.0148	0.1188
25.0	0.0400	0.0324	0.0487	0.0285	0.0268	0.0259	0.0179	0.0759	0.0137	0.0894	0.0108	0.1013
30.0	0.0333	0.0267	0.0410	0.0233	0.0218	0.0211	0.0142	0.0658	0.0107	0.0780	0.0084	0.0890

Table XV

VALUES OF "s" FOR ADIABATIC EXPANSION OF STEAM.

A. Expansion of Water from 200 Lbs. Abs.

Values of s for 10-lb. Intervals.			Values of s for Whole Range.		
Pressure.	Calculated.	Corrected.	200 Lbs. to	Calculated.	Corrected.
200–190	.0987	.1	190	.0987	.100
190–180	.1435	.141	180	.1175	.118
180–170	.1847	.182	170	.1348	.135
170–160	.2304	.223	160	.1519	.153
160–150	.2671	.264	150	.1682	.168
150–140	.3069	.305	140	.1843	.184
140–130	.3509	.346	130	.2007	.202
130–120	.3911	.387	120	.2172	.218
120–110	.4304	.428	110	.2341	.235
110–100	.4738	.470	100	.2517	.252
100– 90	.5166	.510	90	.2699	.270
90– 80	.5512	.551	80	.2889	.290
80– 70	.5897	.592	70	.3089	.310
70– 60	.6320	.633	60	.3306	.332
60– 50	.6790	.674	50	.3547	.356
50– 40	.7147	.716	40	.3811	.382
40– 30	.7658	.760	30	.4125	.412
30– 20	.8150	.808	20	.4518	.448
20– 10	.8718	.870	10	.5085	.504
10– 1	1.0557	1.042	1	.6381	.638

B. Expansion of Dry Saturated Steam from 200 Lbs. Abs.

Values of s for 10-lb. Intervals.			Values of s for Whole Range.		
Range.	Calculated.	Corrected.	200 Lbs. to	Calculated.	Corrected.
200–190	1.132	1.145	190	1.132	1.143
190–180	1.153	1.145	180	1.143	1.143
180–170	1.142	1.145	170	1.143	1.143
170–160	1.148	1.145	160	1.144	1.143
160–150	1.138	1.144	150	1.143	1.143
150–140	1.128	1.144	140	1.140	1.143
140–130	1.150	1.143	130	1.142	1.142
130–120	1.130	1.143	120	1.140	1.142
120–110	1.135	1.142	110	1.139	1.142
110–100	1.137	1.141	100	1.139	1.141
100– 90	1.148	1.140	90	1.140	1.140
90– 80	1.126	1.138	80	1.138	1.139
80– 70	1.144	1.137	70	1.139	1.139
70– 60	1.138	1.136	60	1.138	1.138
60– 50	1.125	1.135	50	1.137	1.137
50– 40	1.143	1.133	40	1.138	1.136
40– 30	1.131	1.131	30	1.136	1.135
30– 20	1.131	1.130	20	1.135	1.134
20– 10	1.125	1.128	10	1.133	1.131
10– 1	1.124	1.126	1	1.124	1.127

C. Expansion of Steam. Superheated throughout Expansion, from 200 Lbs. Abs. and 540° Superheat.

Values of s for 10-lb. Intervals.			Values of s for Whole Range.		
Pressure.	Calculated.	Corrected.	200 Lbs. to	Calculated.	Corrected.
200–190	1.354	1.342	190	1.354	1.342
190–180	1.314	1.342	180	1.333	1.342
180–170	1.455	1.342	170	1.374	1.342
170–160	1.257	1.342	160	1.340	1.342
160–150	1.403	1.341	150	1.354	1.341
150–140	1.213	1.341	140	1.323	1.341
140–130	1.422	1.341	130	1.340	1.341
130–120	1.343	1.340	120	1.340	1.340
120–110	1.329	1.340	110	1.339	1.339
110–100	1.332	1.339	100	1.338	1.339
100– 90	1.338	1.338	90	1.338	1.338
90– 80	1.287	1.336	80	1.331	1.336
80– 70	1.331	1.335	70	1.331	1.335
70– 60	1.340	1.334	60	1.332	1.334
60– 50	1.315	1.332	50	1.330	1.332
50– 40	1.327	1.330	40	1.329	1.330
40– 30	1.318	1.327	30	1.328	1.327
30– 20	1.328	1.325	20	1.328	1.325
20– 10	1.323	1.322	10	1.327	1.322

D. Expansion of Steam Initially Superheated and Finally Wet, from 200 Lbs. Abs. and 150° Superheat.
(Note.—Crosses saturation line at 70 lbs. abs.)

Values of s for 10-lb. Intervals.			Values of s for Whole Range.		
Range.	Calculated.	Corrected.	200 Lbs. to	Calculated.	Corrected.
200–190	1.249	1.334	190	1.249	1.339
190–180	1.365	1.332	180	1.306	1.338
180–170	1.396	1.330	170	1.336	1.337
170–160	1.333	1.327	160	1.336	1.336
160–150	1.314	1.324	150	1.331	1.335
150–140	1.325	1.321	140	1.330	1.333
140–130	1.357	1.316	130	1.334	1.332
130–120	1.302	1.312	120	1.329	1.330
120–110	1.303	1.306	110	1.325	1.328
110–100	1.270	1.300	100	1.317	1.326
100– 90	1.396	1.292	90	1.328	1.323
90– 80	1.311	1.283	80	1.325	1.320
80– 70	1.337	1.272	70	1.327	1.316
70– 60	1.230	1.156	60	1.314	1.304
60– 50	1.150	1.150	50	1.290	1.289
50– 40	1.144	1.146	40	1.268	1.270
40– 30	1.138	1.140	30	1.246	1.250
30– 20	1.093	1.134	20	1.216	1.226
20– 10	1.157	1.127	10	1.202	1.200
10– 1	1.116	1.120	1	1.163	1.176

Note. Irregularities in values of s have been corrected by plotting a smooth curve through calculated values, and taking corrected values from this curve.

Table XVI

VALUES OF s IN THE EQUATION PV^s = CONSTANT FOR VARIOUS SUBSTANCES AND CONDITIONS

Substance.		s	Remarks or Authority.
All gases	Isothermal	1	Accepted thermodynamic law
All gases and vapors	Constant pressure	0	
All saturated vapors	Isothermal	0	
All gases and vapors	Constant volume	∞	
Air	Adiabatic	1.4066	Smithsonian Tables
Air	Compressed in cylinder	1.4	Experience
Ammonia (NH_3)	Adiabatic, wet	1.1	Average
Ammonia (NH_3)	Adiabatic, superheated	1.3	Thermodynamics
Bromine	Adiabatic	1.293	Strecker
Carbon dioxide (CO_2)	Adiabatic	1.300	Röntgen, Wullner
Carbon monoxide (CO)	Adiabatic	1.403	Cazin, Wullner
Carbon disulphide (CS_2)	Adiabatic	1.200	Beyne
Chlorine (Cl)	Adiabatic	1.323	Strecker
Chloroform ($CCl_3CH(OH)_2$)	Adiabatic	1.106	Beyne, Wullner
Ether ($C_2H_5OC_2H_5$)	Adiabatic	1.029	Müller
Hydrogen (H_2)	Adiabatic	1.410	Cazin
Hydrogen sulph. (H_2S)	Adiabatic	1.276	Müller
Methane (CH_4)	Adiabatic	1.316	Müller
Nitrogen (N_2)	Adiabatic	1.410	Cazin
Nitrous oxide (NO_2)	Adiabatic	1.291	Wullner
Pintsch gas	Adiabatic	1.24	Pintsch Co.
Sulphide diox (SO_2)	Adiabatic	1.26	Cazin, Müller
Steam, superheated	Adiabatic	1.300	Smithsonian Tables
Steam, wet	Adiabatic	Variable	(From less than 1 to more than 1.2)
Steam, wet	Adiabatic	1.111	Rankine
Steam, wet	Adiabatic	1+.14×% moist.	Perry
Steam, wet	Adiabatic	1.035+1.0×% moist.	Gray
Steam, wet	Expanding in cylinder	1.	Average from practice
Steam, dry	Saturation law	1.0646	Regnault

Table XVII

FIXED TEMPERATURES

U. S. BUREAU OF STANDARDS

Temperature, ° C.	Temperature, ° F.	Determined by the Point at which
232	449	Liquid tin solidifies
327	621	Liquid lead solidifies
419.4	787	Liquid zinc solidifies
444.7	832.5	Liquid sulphur boils
630.5	1167	Liquid antimony solidifies
658	1216	Liquid aluminum, 97.7% pure, solidifies
1064	1947	Solid gold melts
1084	1983	Liquid copper solidifies
1435	2615	Solid nickel melts
1546	2815	Solid palladium melts
1753	3187	Solid platinum melts

Table XVIII

TEMPERATURES, CENTIGRADE AND FAHRENHEIT

C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
−40	−40.	26	78.8	92	197.6	158	316.4	224	435.2	290	554	950	1742
−39	−38.2	27	80.6	93	199.4	159	318.2	225	437.	300	572	960	1760
−38	−36.4	28	82.4	94	201.2	160	320.	226	438.8	310	590	970	1778
−37	−34.6	29	84.2	95	203.	161	321.8	227	440.6	320	608	980	1796
−36	−32.8	30	86.	96	204.8	162	323.6	228	442.4	330	626	990	1814
−35	−31.	31	87.8	97	206.6	163	325.4	229	444.2	340	644	1000	1832
−34	−29.2	32	89.6	98	208.4	164	327.2	230	446.	350	662	1010	1850
−33	−27.4	33	91.4	99	210.2	165	329.	231	447.8	360	680	1020	1868
−32	−25.6	34	93.2	100	212.	166	330.8	232	449.6	370	698	1030	1886
−31	−23.8	35	95.	101	213.8	167	332.6	233	451.4	380	716	1040	1904
−30	−22.	36	96.8	102	215.6	168	334.4	234	453.2	390	734	1050	1922
−29	−20.2	37	98.6	103	217.4	169	336.2	235	455.	400	752	1060	1940
−28	−18.4	38	100.4	104	219.2	170	338.	236	456.8	410	770	1070	1958
−27	−16.6	39	102.2	105	221.	171	339.8	237	458.6	420	788	1080	1976
−26	−14.8	40	104.	106	222.8	172	341.6	238	460.4	430	806	1090	1994
−25	−13.	41	105.8	107	224.6	173	343.4	239	462.2	440	824	1100	2012
−24	−11.2	42	107.6	108	226.4	174	345.2	240	464.	450	842	1110	2030
−23	− 9.4	43	109.4	109	228.2	175	347.	241	465.8	460	860	1120	2048
−22	− 7.6	44	111.2	110	230.	176	348.8	242	467.6	470	878	1130	2066
−21	− 5.8	45	113.	111	231.8	177	350.6	243	469.4	480	896	1140	2084
−20	− 4.	46	114.8	112	233.6	178	352.4	244	471.2	490	914	1150	2102
−19	− 2.2	47	116.6	113	235.4	179	354.2	245	473.	500	932	1160	2120
−18	− 0.4	48	118.4	114	237.2	180	356.	246	474.8	510	950	1170	2138
−17	+ 1.4	49	120.2	115	239.	181	357.8	247	476.6	520	968	1180	2156
−16	3.2	50	122.	116	240.8	182	359.6	248	478.4	530	986	1190	2174
−15	5.	51	123.8	117	242.6	183	361.4	249	480.2	540	1004	1200	2192
−14	6.8	52	125.6	118	244.4	184	363.2	250	482.	550	1022	1210	2210
−13	8.6	53	127.4	119	246.2	185	365.	251	483.8	560	1040	1220	2228
−12	10.4	54	129.2	120	248.	186	366.8	252	485.6	570	1058	1230	2246
−11	12.2	55	131.	121	249.8	187	368.6	253	487.4	580	1076	1240	2264
−10	14.	56	132.8	122	251.6	188	370 4	254	489.2	590	1094	1250	2282
− 9	15.8	57	134.6	123	253.4	189	372.2	255	491.	600	1112	1260	2300
− 8	17.6	58	136.4	124	255.2	190	374.	256	492.8	610	1130	1270	2318
− 7	19.4	59	138.2	125	257.	191	375.8	257	494.6	620	1148	1280	2336
− 6	21.2	60	140.	126	258.8	192	377.6	258	496.4	630	1166	1290	2354
− 5	23.	61	141.8	127	260.6	193	379.4	259	498.2	640	1184	1300	2372
− 4	24.8	62	143.6	128	262.4	194	381.2	260	500.	650	1202	1310	2390
− 3	26.6	63	145.4	129	264.2	195	383.	261	501.8	660	1220	1320	2408
− 2	28.4	64	147.2	130	266.	196	384.8	262	503.6	670	1238	1330	2426
− 1	30.2	65	149.	131	267.8	197	386.6	263	505.4	680	1256	1340	2444
0	32.	66	150.8	132	269.6	198	388.4	264	507.2	690	1274	1350	2462
+ 1	33.8	67	152.6	133	271.4	199	390.2	265	509.	700	1292	1360	2480
2	35.6	68	154.4	134	273.2	200	392.	266	510.8	710	1310	1370	2498
3	37.4	69	156.2	135	275.	201	393.8	267	512.6	720	1328	1380	2516
4	39.2	70	158.	136	276.8	202	395.6	268	514.4	730	1346	1390	2534
5	41.	71	159.8	137	278.6	203	397.4	269	516.2	740	1364	1400	2552
6	42.8	72	161.6	138	280.4	204	399.2	270	518.	750	1382	1410	2570
7	44.6	73	163.4	139	282.2	205	401.	271	519.8	760	1400	1420	2588
8	46.4	74	165.2	140	284.	206	402.8	272	521.6	770	1418	1430	2606
9	48.2	75	167.	141	285.8	207	404.6	273	523.4	780	1436	1440	2624
10	50.	76	168.8	142	287.6	208	406.4	274	525.2	790	1454	1450	2642
11	51.8	77	170.6	143	289.4	209	408.2	275	527.	800	1472	1460	2660
12	53.6	78	172.4	144	291.2	210	410.	276	528.8	810	1490	1470	2678
13	55.4	79	174.2	145	293.	211	411.8	277	530.6	820	1508	1480	2696
14	57.2	80	176.	146	294.8	212	413.6	278	532.4	830	1526	1490	2714
15	59.	81	177.8	147	296.6	213	415.4	279	534.2	840	1544	1500	2732
16	60.8	82	179.6	148	298.4	214	417.2	280	536.	850	1562	1510	2750
17	62.6	83	181.4	149	300.2	215	419.	281	537.8	860	1580	1520	2768
18	64.4	84	183.2	150	302.	216	420.8	282	539.6	870	1598	1530	2786
19	66.2	85	185.	151	303.8	217	422.6	283	541.4	880	1616	1540	2804
20	68.	86	186.8	152	305.6	218	424.4	284	543.2	890	1634	1550	2822
21	69.8	87	188.6	153	307.4	219	426.2	285	545.	900	1652	1600	2912
22	71.6	88	190.4	154	309.2	220	428.	286	546.8	910	1670	1650	3002
23	73.4	89	192.2	155	311.	221	429.8	287	548.6	920	1688	1700	3092
24	75.2	90	194.	156	312.8	222	431.6	288	550.4	930	1706	1750	3182
25	77.	91	195.8	157	314.6	223	433.4	289	552.2	940	1724	1800	3272

Table XVIII—*Continued*

TEMPERATURES, FAHRENHEIT AND CENTIGRADE

F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.
−40	−40.	26	− 3.3	92	33.3	158	70.	224	106.7	290	143.3	360	182.2
−39	−39.4	27	− 2.8	93	33.9	159	70.6	225	107.2	291	143.9	370	187.8
−38	−38.9	28	− 2.2	94	34.4	160	71.1	226	107.8	292	144.4	380	193.3
−37	−38.3	29	− 1.7	95	35.	161	71.7	227	108.3	293	145.	390	198.9
−36	−37.8	30	− 1.1	96	35.6	162	72.2	228	108.9	294	145.6	400	204.4
−35	−37.2	31	− 0.6	97	36.1	163	72.8	229	109.4	295	146.1	410	210.
−34	−36.7	32	0.	98	36.7	164	73.3	230	110.	296	146.7	420	215.6
−33	−36.1	33	+ 0.6	99	37.2	165	73.9	231	110.6	297	147.2	430	221.1
−32	−35.6	34	1.1	100	37.8	166	74.4	232	111.1	298	147.8	440	226.7
−31	−35.	35	1.7	101	38.3	167	75.	233	111.7	299	148.3	450	232.2
−30	−34.4	36	2.2	102	38.9	168	75.6	234	112.2	300	148.9	460	237.8
−29	−33.9	37	2.8	103	39.4	169	76.1	235	112.8	301	149.4	470	243.3
−28	−33.3	38	3.3	104	40.	170	76.7	236	113.3	302	150.	480	248.9
−27	−32.8	39	3.9	105	40.6	171	77.2	237	113.9	303	150.6	490	254.4
−26	−32.2	40	4.4	106	41.1	172	77.8	238	114.4	304	151.1	500	260.
−25	−31.7	41	5.	107	41.7	173	78.3	239	115.	305	151.7	510	265.6
−24	−31.1	42	5.6	108	42.2	174	78.9	240	115.6	306	152.2	520	271.1
−23	−30.6	43	6.1	109	42.8	175	79.4	241	116.1	307	152.8	530	276.7
−22	−30.	44	6.7	110	43.3	176	80.	242	116.7	308	153.3	540	282.2
−21	−29.4	45	7.2	111	43.9	177	80.6	243	117.2	309	153.9	550	287.8
−20	−28.9	46	7.8	112	44.4	178	81.1	244	117.8	310	154.4	560	293.3
−19	−28.3	47	8.3	113	45.	179	81.7	245	118.3	311	155.	570	298.9
−18	−27.8	48	8.9	114	45.6	180	82.2	246	118.9	312	155.6	580	304.4
−17	−27.2	49	9.4	115	46.1	181	82.8	247	119.4	313	156.1	590	310.
−16	−26.7	50	10.	116	46.7	182	83.3	248	120.	314	156.7	600	315.6
−15	−26.1	51	10.6	117	47.2	183	83.9	249	120.6	315	157.2	610	321.1
−14	−25.6	52	11.1	118	47.8	184	84.4	250	121.1	316	157.8	620	326.7
−13	−25.	53	11.7	119	48.3	185	85.	251	121.7	317	158.3	630	332.2
−12	−24.4	54	12.2	120	48.9	186	85.6	252	122.2	318	158.9	640	337.8
−11	−23.9	55	12.8	121	49.4	187	86.1	253	122.8	319	159.4	650	343.3
−10	−23.3	56	13.3	122	50.	188	86.7	254	123.3	320	160.	660	348.9
− 9	−22.8	57	13.9	123	50.6	189	87.2	255	123.9	321	160.6	670	354.4
− 8	−22.2	58	14.4	124	51.1	190	87.8	256	124.4	322	161.1	680	360.
− 7	−21.7	59	15.	125	51.7	191	88.3	257	125.	323	161.7	690	365.6
− 6	−21.1	60	15.6	126	52.2	192	88.9	258	125.6	324	162.2	700	371.1
− 5	−20.6	61	16.1	127	52.8	193	89.4	259	126.1	325	162.8	710	376.7
− 4	−20.	62	16.7	128	53.3	194	90.	260	126.7	326	163.3	720	382.2
− 3	−19.4	63	17.2	129	53.9	195	90.6	261	127.2	327	163.9	730	387.8
− 2	−18.9	64	17.8	130	54.4	196	91.1	262	127.8	328	164.4	740	393.3
− 1	−18.3	65	18.3	131	55.	197	91.7	263	128.3	329	165.	750	398.9
0	−17.8	66	18.9	132	55.6	198	92.2	264	128.9	330	165.6	760	404.4
+ 1	−17.2	67	19.4	133	56.1	199	92.8	265	129.4	331	166.1	770	410.
2	−16.7	68	20.	134	56.7	200	93.3	266	130.	332	166.7	780	415.6
3	−16.1	69	20.6	135	57.2	201	93.9	267	130.6	333	167.2	790	421.1
4	−15.6	70	21.1	136	57.8	202	94.4	268	131.1	334	167.8	800	426.7
5	−15.	71	21.7	137	58.3	203	95.	269	131.7	335	168.3	810	432.2
6	−14.4	72	22.2	138	58.9	204	95.6	270	132.2	336	168.9	820	437.8
7	−13.9	73	22.8	139	59.4	205	96.1	271	132.8	337	169.4	830	443.3
8	−13.3	74	23.3	140	60.	206	96.7	272	133.3	338	170.	840	448.9
9	−12.8	75	23.9	141	60.6	207	97.2	273	133.9	339	170.6	850	454.4
10	−12.2	76	24.4	142	61.1	208	97.8	274	134.4	340	171.1	860	460.
11	−11.7	77	25.	143	61.7	209	98.3	275	135.	341	171.7	870	465.6
12	−11.1	78	25.6	144	62.2	210	98.9	276	135.6	342	172.2	880	471.1
13	−10.6	79	26.1	145	62.8	211	99.4	277	136.1	343	172.8	890	476.7
14	−10.	80	26.7	146	63.3	212	100.	278	136.7	344	173.3	900	482.2
15	− 9.4	81	27.2	147	63.9	213	100.6	279	137.2	345	173.9	910	487.8
16	− 8.9	82	27.8	148	64.4	214	101.1	280	137.8	346	174.4	920	493.3
17	− 8.3	83	28.3	149	65.	215	101.7	281	138.3	347	175.	930	498.9
18	− 7.8	84	28.9	150	65.6	216	102.2	282	138.9	348	175.6	940	504.4
19	− 7.2	85	29.4	151	66.1	217	102.8	283	139.4	349	176.1	950	510.
20	− 6.7	86	30.	152	66.7	218	103.3	284	140.	350	176.7	960	515.6
21	− 6.1	87	30.6	153	67.2	219	103.9	285	140.6	351	177.2	970	521.
22	− 5.6	88	31.1	154	67.8	220	104.4	286	141.1	352	177.8	980	526.7
23	− 5.	89	31.7	155	68.3	221	105.	287	141.7	353	178.3	990	532.2
24	− 4.4	90	32.2	156	68.9	222	105.6	288	142.2	354	178.9	1000	537.8
25	− 3.9	91	32.8	157	69.4	223	106.1	289	142.8	355	179.4	1010	543.3

The missing water, or difference between the actual steam consumption of an engine and that shown by the indicator cards is given by Prof. Heck as:

$$\frac{\text{Missing water}}{\text{Indicated steam}}=\frac{0.27}{\sqrt[3]{N}}\sqrt{\frac{S(x_2-x_1)}{p_1Z}}$$

in which S = the ratio of cylinder-displacement surface in sq. ft. to displacement in cu. ft., or

$$S=\frac{2}{L}+\frac{d}{48};\ Z=\text{fraction of card length completed at cut-off;—}$$

N = R.P.M. of engine; d = dia. cyl. in in.; L = stroke in ft.

The term (x_2-x_1) is to be supplied from Table XIX and is the difference between the x for the high pressure and that for the low pressure, both absolute.

Table XIX

VALUES OF x FOR USE IN HECK'S FORMULA FOR MISSING WATER

Absolute Steam Pressure.	x	Absolute Steam Pressure.	x	Absolute Steam Pressure.	x
0	170	70	297.5	165	393
1	175	75	304	170	397
2	179	80	310	180	405
3	183	85	316	185	409
4	186	90	321.5	190	413
6	191	95	327	195	416.5
8	196	100	332.5	200	420
10	200	105	338	210	427
15	210	110	343	220	434
20	220	115	348	230	441
25	229	120	353	240	447.5
30	238	125	358	250	454
35	246	130	362.5	260	460.5
40	254	135	367	270	467
45	262	140	371.5	280	473
50	269.5	145	376	290	479
55	277	150	380.5	300	485
60	284	155	385		
65	291	160	389		

Table XX

BAUMÉ SPECIFIC GRAVITY SCALE

Specific gravities are for 60° F. referred to water at same temperature as unity, at which temperature it weighs 62.34 lbs. per cubic foot.

Tabular results are calculated from:

$$\text{Degrees Baumé} = \begin{cases} \left(145 - \dfrac{145}{\text{specific gravity}}\right) & \text{for liquids heavier than water.} \\ \left(\dfrac{140}{\text{specific gravity}} - 130\right) & \text{for liquids lighter than water.} \end{cases}$$

Relation between Specific Gravity and Baume

Specific Gravity	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
	Degrees Baumé.									
.60	103.33	99.51	95.81	92.22	88.75	85.38	82.12	78.95	75.88	72.90 [1]
.70	70.00	67.18	64.44	61.78	59.19	56.67	54.21	51.82	49.49	47.22 [1]
.80	45.00	42.84	40.73	36.68	36.67	34.71	32.79	30.92	29.09	27.30 [1]
.90	25.56	23.85	22.17	20.54	18.94	17.37	15.83	14.33	12.86	11.41 [1]
1.00	10.00									
1.00	0.00	1.44	2.84	4.22	5.58	6.91	8.21	9.49	10.74	11.97 [2]
1.10	13.18	14.37	15.54	16.68	17.81	18.91	20.00	21.07	22.12	23.15 [2]
1.20	24.17	25.16	26.15	27.11	28.06	29.00	29.92	30.83	31.72	32.60 [2]
1.30	33.46	34.41	35.15	35.98	36.79	37.50	38.38	39.16	39.93	40.68 [2]
1.40	41.43	42.16	42.89	43.60	44.31	45.00	45.68	41.36	47.03	47.68 [2]
1.50	48.33	48.97	49.60	50.23	50.84	51.45	52.05	52.62	53.23	53.80 [2]

Adapted from Smithsonian Tables No. 65.

[1] Specific gravity less than 1.00 particularly useful for liquids fuel, oils, and alcohols.
[2] Specific gravities greater than 1.00 particularly useful for non-freezing brines.

Table XXI

FREEZING-POINT OF CALCIUM CHLORIDE

U. S. Bureau of Standards

Density of Solution.	Per cent $CaCl_2$ by Wt.	Freezing-point, ° C.	Freezing-point, ° F.
1.12	14.88	− 9	15.8
1.14	16.97	−13	8.6
1.16	19.07	−16	3.2
1.18	21.13	−20	− 4.0
1.20	23.03	−24	−11.2
1.22	24.89	−29	−20.2
1.24	26.77	−34	−29.2
1.26	28.55	−40	−40.0

TABLE

SPECIFIC HEATS

Class.	Substance.	Atomic Weight H = 1.	Specific Gravity.	Authority.
Elements	Aluminum	26.9	2.57	Mallet
	Carbon (amorphous)	11.99	....	....
	Carbon graph.	11.99	2.10–2.32	Smithsonian Tables
	Copper (cast)	63.07	8.8–8.95	Smithsonian Tables
	Iron (pure)	55.41	7.85	Smithsonian Tables
	Iron (pure)	55.41	7.85	Smithsonian Tables
	Lead (cast)	205.46	11.37	Reich
	Mercury	198.5	14.18	Mallet
	Nickel	58.21	8.65	Smithsonian Tables
	Tin (cast)	118.1	7.29	Mathiessen
	Zinc (cast)	64.88	7.05	Smithsonian Tables
Common substances	Bronze	......	8.75–9	Smithsonian Tables
	Brass	......	7.8–8.6	Smithsonian Tables
	Brick work, Masonry	......	1.84–2.3	Smithsonian Tables
	Butter	......	.865	Smithsonian Tables
	Clay	......	1.80–2.6	Smithsonian Tables
	Coal	......	1.2–1.5	Smithsonian Tables
	Wood	......	.4–1.2	Smithsonian Tables
	Glass	......	2.4–2.8	Smithsonian Tables
	Ice	......	.9	Smithsonian Tables
	Cast Iron	......	6.8–7.5	*
	Wrought Iron	......	7.4–7.9	*
	Marble	......	2.5–2.8	Smithsonian Tables
	Steel	......	7.7–7.9	*
	Sand	......	1.45–1.6	Smithsonian Tables
	Stone	......	2.1–3.4	*

* Kent's Mechanical Engineers' Pocketbook.

XXII

OF SOLIDS

Specific Heat.	At Temperature. C.	At Temperature. F.	Specific Heat Calculated from Atomic Weights.	Authority.
.2089	0	32	.238	Bontschew
.2226	20–100	68–212	....	Bontschew
.2739	500	932	....	Bontschew
.241	0	32	....	Olsen
.1138	−50	−58	....	Weber
.1605	+11	52	....	Weber
.467	977	1795	....	Weber
.310	16–1000	61–1832	....	Dewar
.0924	17	62	.102	Naccari
.0985	300	572	....	Naccari
.1162	0	32	.117	Olsen
.1091	15	59	....	Naccari
.1376	300	572	....	Naccari
.1765	500	392	.117	Pionchon
.218	720–1000	1328–1832	....	Pionchon
.1989	1000–1200	1832–2192	....	Pionchon
.0299	15	59	.031	Naccari
.0324	200	392	....	Naccari
.0319	−78 to −40	−108 to −40	.0323	Regnault
.1084	21–99	69–210	.11	Voigt
.1233	500	932	....	Tilden
.1608	1000	1832	....	Pionchon
.0545	0–100	32–212	.052	Bunsen
.0538	16–197	69–387	....	Spring
.0915	18	64	.099	Naccari
.0996	200	392	....	Naccari
.0935	0–100	32–212	....	Bunsen
.0858	15–98	59–208	....	Regnault
.0939	....	....	....	Regnault
About .2	....	....	....	*
.55	....	....	....	Siebel
.197	....	....	....	Regnault
.2–.241	....	....	....	Regnault
.45–.65	....	....	....	*
.16–.18	....	....	....	Regnault
.504	....	....	....	Regnault
.1298	....	....	....	Regnault
.1138	....	....	....	Regnault
.21	....	....	....	Regnault
.1165–.1175	....	....	....	Regnault
.195	....	....	....	*
.2–.22	....	....	....	*

* Kent's Mechanical Engineers' Pocketbook.

TABLE

SPECIFIC HEATS OF GASES:

Substance.	C_p	At Temperature. ° C.	At Temperature. ° F.	Authority.	C_v
Hydrogen, H_2	3.3996	−28–+9	−18.4–15.8	Regnault	2.4219
	3.409	12–198	53.6–388.4	Regnault	
	3.410	21–100	70–212	Wiedeman	
Oxygen, O_2	.2175	13–207	55–405	Regnault	.1603
	.2240	20–440	68–824	Holborn-Austin	
	.2300	20–630	68–166	Holborn-Austin	
Nitrogen, N_2	.2438	0–200	22–392	Regnault	.1715
	.2419	20–440	68–824	Holborn-Austin	
	.2464	20–630	68–1166	Holborn-Austin	
	.2497	20–800	68–1472	Holborn-Austin	
Air	.2377	−30–+10	32-50	Regnault	
	.2374	0–100	32–212	Regnault	
	.2375	0–200	32–392	Regnault	.1703
	.2366	20–440	68–824	Holborn-Austin	
	.2429	20–630	68–1166	Holborn-Austin	
	.2430	20–800	68–1472	Holborn-Austin	
	.2389	20–100	68–212	Wiedeman	
Ammonia, NH_3	.5202	23–100	73–212	Wiedeman	.4011
	.5356	27–200	80–392	Wiedeman	
	.5125	24–216	75–421	Regnault	
Carbon diox., CO_2	.1843	−28–+7	—18-45	Regnault	
	.2025	15–100	59–212	Regnault	.1558
	.2169	11–214	52–417	Regnault	
Carbon monoxide	.2425	23–99	74–210	Wiedeman	.1734
	.2426	26–198	79–388	Wiedeman	
Methane, CH_4	.5929	18–208	64–406	Regnault	.4505
Benzole, C_6H_6	.2990	34–115	93–239	Wiedeman	.2131
	.3325	35–180	95–356	Wiedeman	
	.3754	116–218	241–424	Regnault	
Ethylene, C_2H_4	.4040	10–202	50–396	Regnault	.3404

XXIII

RATIOS AND DIFFERENCES

Determined from	$C_p - C_v$	$777.52(C_p\text{-}C_v) = \left(\frac{PV}{T}\right)$ in ft.-lbs.	$C_p \div C_v = \gamma$
Wiedeman $C_p = 3.41$ and $\frac{C_p}{C_v} = 1.408$ at $4° - 16°$ C. by Lummer and Pringsheim	.9881	768.267	1.408
Holborn and Austin $C_p = .2240$ and $\frac{C_p}{C_v} = 1.3977$ at 5° to 14° C.	.0637	49.528	1.3977
Holborn and Austin $C_p = .2419$ and $\frac{C_p}{C_v} = 1.41$ by Cazin	.0704	54.737	1.4105
Wiedeman $C_p = .2389$ and $\frac{C_p}{C_v} = 1.4025$ at 5° to 14° C. by Lummer and Pringsheim	.0686	53.338	1.4028
Wiedeman $C_p = .5202$ and mean of $\left(\frac{C_p}{C_v} = 1.3172 \text{ at } 0° \text{ C. and } \frac{C_p}{C_v} = 1.2770 \text{ at } 100° \text{ C.}\right)$ $= 1.2971$ by Wüllner	.1191	92.603	1.2969
Regnault $C_p = .2025$ and $\frac{C_p}{C_v} = 1.2995$ by Lummer and Pringsheim	.0467	36.310	1.2997
Wiedeman $C_p = .2425$ and mean of $\left(\frac{C_p}{C_v} = 1.4032 \text{ at } 0° \text{ C. and } \frac{C_p}{C_v} = 1.3946 \text{ at } 100° \text{ C.}\right)$ $= 1.3939$ by Wüllner	.0691	53.726	1.3985
Regnault $C_p = .5929$ $\frac{C_p}{C_v} = 1.316$ at 30° C. by Müller	.1424	110.719	1.316
Wiedeman $C_p = .2990$ and $\frac{C_p}{C_v} = 1.403$ at 60° C. by Pagliani	.0859	66.789	1.4031
Regnault $C_p = .4040$ and $\frac{C_p}{C_v} = 1.1870$ at 100° C. by Wüllner	.0636	49.450	1.1867

TABLE XXIV

SPECIFIC HEATS OF LIQUIDS

Class.	Substance.	Atomic Weight, H = 1.	Specific Gravity.	Authority.	Specific Heat.	At. Temperature.		Specific Heat Calculated from At. Wt.	Authority.
						° C.	° F.		
Elements:	Bismuth	206.3	10.	Vincentini-Omodei	.0363	280–380	536–716	.031	Person
"	Lead	205.5	10.6	Vincentini-Omodei	.0356	310	590	.0311	Spring
					.041	360	680	.....	Spring
"	Mercury	198.5	13.5	Regnault	.0335	0	32	.0322	Olsen
"	Tin	118.1	6.97	Smithsonian Tables	.0637	250–350	482–662	.....	Person
					.0758	1100	2012	.0541	Pionchon
Common substances:	Alcohol, ethyl	....	.79	Smithsonian Tables	.5053	−20	−4	.....	Regnault
					.6479	40	104	.....	Regnault
"	Alcohol, methyl	....	.808	Smithsonian Tables	.590	5–10	41–50	.....	Regnault
"	Benzene	....	.899	Smithsonian Tables	.3402	10	50–104	.....	De Heen
					.4233	40	....	.....	Deruyts
"	Glycerine	....	1.255	Smithsonian Tables	.576	15–50	59–122	.....	Emo
"	Vegetable oil	....	about .9	Smithsonian Tables	about .4	0–10	32–50	.....	Wachsmuth
									Weber
"	Petroleum	....	.88	Kent	.511	21–58	70–136	.....	Pagliani
"	Kerosene	....	.8–.82	Kent	.4747–.4766	10–20	50–68	.....	Gill
					.4903–.4997	20–30	68–96	.....	Gill
"	Gasolene	....	.68–.7	Kent	.5332–.5375	10–20	50–68	.....	Gill
					.5032–.555	20–30	68–98	.....	Gill
"	Aqua ammonia	....	.9–1	Starr	....	....	....	.....	
"	Sea water	....	1.0043	....	.98	17.5	63.5	.....	Thomsen
"	Sea water	....	1.0235	....	.938	17.5	63.5	.....	Thomsen
"	Sea water	....	1.0463	....	.903	17.5	63.5	.....	Thomsen

Table XXV
SPECIFIC HEAT OF SODIUM CHLORIDE BRINE

Density, Bé	Sp.gr.	Per cent NaCl by Wt.	Sp. Heat.	Temp. F.	Authority.
1	1.007	1	.992	−0	Common
....	....	1.6	978	64.4	Thomsen
....	....	4.9	.995	66−115	Winkelmann
5	1.037	5.0	.960	−0	Common
10	1.073	10.0	.892	−0	Common
....	....	10.3	.892	59−120	Teudt
....	....	10.3	.912	59−194	Teudt
....	....	11.5	.887	61−126	Marignac
....	....	12.3	.871	64.4	Winkelmann
15	1.115	15.0	.892	−0	Common
....	....	18.8	.841	63−125	Teudt
....	....	18.8	.854	68−192	Teudt
19	1.150	20.0	.829		Common
....	....	24.3	.7916	64−68	Winkelmann
....	....	24.5	.791	64	Thomsen
23	1.191	25	.783		Common

Table XXVI
COEFFICENT OF LINEAR EXPANSION OF SOLIDS

Substance.	$\alpha \times 10^4$ per degree C.	At Temp. C.	$\alpha \times 10^4$	At Temp. F.	Authority.
Aluminum..	.2313–.3150	40–600	.1285–.175	104–1112	Fizeau and Le Chatelier
Antimony..	.0882–.1692	40	.049–.094	104	Fizeau
Carbon coke	.054	40	.03	104	“
Carbon graphite..	.0786	40	.0437	104	“
Copper.....	.1678	40	.0932	104	“
Iron.......	.1061–.1210	40	.059–.0672	104	“
Steel.......	.1095–.1322	40	.06085–.0735	104	“
Lead.......	.2924	40	.1625	104	“
Nickel.....	.1279	40	.071	104	“
Platinum...	.0899	40	.05	104	“
Tin........	.2234	40	.1241	104	“
Zinc.......	.2918	40	.1621	104	“
Brasses and bronze....	.17–.21	0–900	.0889–.1167	32–1652	Limits of determination
Rubber....	.770	16.7–25.3	.4278	62–77.5	Kohlrausch
Glass......	.058–.0897	0–100	.03222–.0498	32–212	Limits of determination
Solder......	.2508	0–100	.1338	32–215	Smeaton
Ice........	.375	−20 to −1	.2083	−4–30.2	Brunner
Paraffin....	1.0662–4.7707	0–16; 38–49	.5921; 2.6505	32–60.8 100.4–120	Rodwell
Porcelain...	.0413	20–790	.023	68–145.4	Braun
Wood	.0325–.0614	2–34	.0181–.0341	35.6–93.2	Limits of determination
Wax.......	2.300–15.227	10–26; 43–57	1.278 8.46	50–78.8 109.4–134.6	Kopp
Concrete...	.1430	....	.0795	....	Clark
Masonry...	.046–.089	....	.0256–.0494	....	Clark

Table XXVII

COEFFICIENT OF CUBICAL EXPANSION OF LIQUIDS

Substance.	$\alpha \times 10^2$ per ° C.	At Temp. C.	$\alpha \times 10^2$ per ° F.	At Temp. F.	Authority.
Alcohol (methyl)	.1433	−38–+70	.0796	−36–158	Pierre
Benzene	.1385	11–81	.0770	32–178	Kopp
Bromine	.1168	−7–+60	.0649	19–140	Pierre
Calcium chloride, $CaCl_2$, 5.8 per cent.	.0506	18–25	.0281	64–77	Decker
Calcium chloride, $CaCl_2$, 40.9 per cent.	.0510	17–24	.0283	63–75	Decker
Ether	.2150	−15–+38	.1195	5–100	Pierre
Hydrochloric acid, $HCl+6.25\ H_2O$	.0489	0–30	.0272	32–86	Marignac
Hydrochloric acid, $HCl+50\ H_2O$	.0933	0–30	.0519	32–86	Marignac
Mercury	.0179	....	.0099		
Olive oil	.0742	....	.0412	......	Spring
Phenol, C_6H_6O	.0899	3–157	.0500	97–314	Pinette
Petroleum, Sp.gr. .8467	.1039	24–120	.0577	75–248	Frankenheim
Sodium chloride, NaCl, 1.6 per cent.	.1067	....	.0593	......	Marignac
Sulphuric acid, H_2SO_4	.0489	0–30	.0272	32–86	Marignac
Sulphuric acid, H_2SO_4	.0799	0–30	.0444	32–86	Marignac

Table XXVIII

COEFFICIENT OF VOLUMETRIC EXPANSION OF GASES AND VAPORS AT CONSTANT PRESSURE

(Heated without change of state.)

Substance.	Pressure (Cm Hg)	$\alpha_p \times 100$ per Deg. C.	$\alpha_p \times 100$ per Deg. F.	Authority.
Air	76	.3671	.2040	Regnault
Air	256	.3693	.2055	Regnault
Hydrogen	76	.36613	.2034	Regnault
Hydrogen	254	.36616	.20342	Regnault
Carbon dioxide	76	.3710	.2060	Regnault
Carbon dioxide	252	.3845	.2135	Regnault
Carbon dioxide 0°–64°	17.1 atm.	.5136	.2855	Andrews
Carbon dioxide 84°–100°	17.1 atm.	.4747	.2635	Andrews
Carbon dioxide 0°–7.5°	24.81 atm.	.7000	.38885	Andrews
Carbon dioxide 64°–100°	24.81 atm.	.5435	.3020	Andrews
Carbon dioxide 0°–64°	24.81 atm.	.6204	.3446	Andrews
Carbon dioxide 0°–7.5°	34.49 atm.	1.097	.6100	Andrews
Carbon dioxide 0°–64°	34.49 atm.	.8450	.470	Andrews
Carbon dioxide 0°–100°	34.49 atm.	.6514	.362	Andrews
Carbon monoxide	76	.3669	.204	Regnault
Nitrous oxide	76	.3719	.2065	Regnault
Sulphur dioxide	76	.3903	.217	Regnault
Sulphur dioxide	98	.3980	.221	Regnault
Water vapor (steam) 0°–119	1 atm.	.4187	.23261	Hirn
Water vapor 0°–141°	1 atm.	.4189	.23272	Hirn
Water vapor 0°–162°	1 atm.	.4071	.22617	Hirn
Water vapor 0°–200°	1 atm.	.3938	.21878	Hirn
Water vapor 0°–247°	1 atm.	.3799	.2111	Hirn

Table XXIX

COEFFICIENT OF PRESSURE RISE OF GASES AND VAPORS AT CONSTANT VOLUME

(Heated without change of state.)

Substance.	Pressure (Cm Hg)	$\alpha_v \times 100$ per Deg. C.	$\alpha_v \times 100$ per Deg. F.	Authority.
Air	.6	.3767	.20915	Meleander
Air	1.6	.3703	.2057	Meleander
Air	10.0	.3663	.2035	Meleander
Air	26.0	.3660	.20335	Meleander
Air	37.6	.3662	.20345	Meleander
Air	75.0	.3665	.20360	Meleander
Air	76–83	.3670	.20370	Magnus
Air	11–15	.3648	.20265	Regnault
Air	17–24	.3651	.20285	Regnault
Air	37–51	.3658	.20320	Regnault
Air	76	.3665	.20360	Regnault
Air	200	.3690	.205	Regnault
Air	2000	.3887	.206	Regnault
Air	10000	.4100	.22775	Regnault
Air	76	.3671	.20395	Rowland
Air	1 atm.	.3670	.20290	Jolly
Carbon dioxide	1 atm.	.3706	.2059	Jolly
Carbon dioxide	1 atm.	.3726	.2070	Meleander
Carbon dioxide	76–104	.3686	.20475	Regnault
Carbon dioxide	174	.3752	.2085	Regnault
Carbon dioxide	793	.4252	.2361	Regnault
Carbon dioxide 0°–64°	16.4 atm.	.4754	.2641	Andrews
Carbon dioxide 64°–100°	16.5 atm.	.4607	.256	Andrews
Carbon dioxide 0°–64°	25.87 atm.	.5728	.3182	Andrews
Carbon dioxide 64°–100°	25.87 atm.	.5406	.30035	Andrews
Carbon dioxide 0°–64°	33.53	.6973	.38740	Andrews
Carbon dioxide 64°–100°	33.53	.6334	.35190	Andrews
Carbon monoxide	1 atm.	.3667	.2037	Regnault
Hydrogen	1 atm.	.3669	.20353	Regnault
Hydrogen	1 atm.	.3656	.2031	Jolly
Nitrogen	1 atm.	.3668	.20375	Regnault
Nitrous oxide	1 atm.	.3676	.20410	Regnault
Nitrous oxide	1 atm.	.3705	.206	Jolly
Oxygen	1 atm.	.3674	.2041	Jolly
Sulphur dioxide, SO_2	1 atm.	.3845	.21350	Jolly

TABLE

COMPRESSIBILITY OF GASES BY THEIR ISOTHERMALS. VALUES OF PV AT AND AT 1 ATMOSPHERE

Pressure in Atmosphere.		1	100	200	300	400	500	600
Oxygen at	32° F.	1.000	.9265	.9140	.9624	1.0516	1.1560	1.2690
	211.1	......	......	1.4	1.4529	1.532	1.622	1.7202
	391.1	......	......	1.819	1.8849	1.96	2.05	2.142
Air at	32° F.	1.000	.9730	1.010	1.0974	1.2144	1.3400	1.4700
	210.92	......	......	1.472	1.551	1.668	1.7825	1 908
	392.72	......	......	1.886	1.9866	2.096	2.211	2.3298
Nitrogen at	32° F.	1.000	.9910	1.0390	1.1358	1.2568	1.3900	1.5258
	211.1	......	......	1.4890	1.5903	1.7060	1.8275	1.9548
	391.28	......	......	1.9064	2.1045	2.1324	2.2575	2.3838
Hydrogen at	32° F.	1.000	......	1.1380	1.2090	1.2828	1.3565	1.4322
	210.74	......	......	1.5134	1.5858	1.6588	1.7310	1.8036
	393.5	......	......	1.884	1.956	2.030	2.105	2.1762
Carbon dioxide at	32° F.	1.000	.202	......	.559	......	.891	
	212.	......	1.03	......	.890	......	1.201	
	388.9	......	1.582	......	1.493	......	1.678	
NH_3 at	32° F.	1.000						
	211.28	......	......	.9290	.8625	.832	.7450	.5850
	362.48	......	......	.9750	.9555	.9380	.8875	.8700

Calculated from Smithsonian Tables Nos. 55 and 58, reporting Amagat's results

TABLE XXXI

VALUES OF THE GAS CONSTANT R

	Determined from Specific Heats by $R=777.52(C_p-C_v)$	Determined from Volume of One Lb. at 32° F. and 29.92 ins. Hg.	Authority for Specific Volume.
Hydrogen, H_2	768.267	765.893	Rayleigh
Oxygen, O_2	49.528	48.244	Rayleigh
Nitrogen, N_2	54.737	55.981	Rayleigh
Air	53.338	53.332	Rayleigh and Leduc
Ammonia, NH_3	92.603	90.467	Leduc
Carbon dioxide, CO_2	36.310	35.084	Rayleigh
Carbon monoxide, CO	53.726	55.135	Leduc
Methane, CH_4	110.719	96.200	Thomson
Benzole, C_6H_6	66.789	Liquid at 32°	
Ethylene, C_2H_4	49.450	54.153	Saussure

XXX

VARIOUS PRESSURES AND TEMPERATURES; THE VALUE OF *PV* AT 32° F TAKEN AS 1.00.

700	800	900	1000		
1.3853 1.827 2.2414	1.5032 1.9336 2.3432	1.6200 2.0412 2.4462	1.7350 2.151	Critical point { Pressure 50 atm. Temperature 180.4° F.	Wroblewski
1.6016 2.0328 2.4514	1.7344 2.1592 2.5752	1.8630 2.2896 2.7	1.992 2.415 2.828	Critical point { Pressure 39 atm. Temperature 220° F.	Olszewski
1.6618 2.086 2.5123	1.7920 2.22 2.64	1.9341 2.3544 2.7765	2.0680	Critical point { Pressure 35 atm. Temperature 230.8° F.	Olszewski
1.5043 1.876 2.2484	1.5776 1.9552 2.32	1.6488 2.1096 2.3913	1.7200 2.093	Critical point { Pressure 20 atm. Temperature 390.1° F.	Dewar
....	....	....	1.656 1.999	Critical point { Pressure 27 atm. Temp. +87.66° F.	Andrews
.... .8715	.... .9000	.... .9315	.... .95	Critical point { Pressure 115 atm. Temp. +266° F.	Dewar

and Table 62 Roth's results; also Table 218 reporting miscellaneous data.

Table XXXII

DENSITIES OF GAS AT ONE ATMOSPHERE = 29.92″ Hg AND 32° F., COMPARING EXPERIMENTAL VALUES WITH COMPUTED VALUES FROM MOLECULAR WEIGHTS

Gas.	Sp.Gr. Air = 1.	Lbs. per Cu.ft. Exptl.	Cu.ft. per Lb.	Authority.	Molecular Weight Exact. H = 2.	Lbs. Cu.ft. from Exact Molecular Weight.	Molecular Weight Approx. H = 2.	Lbs. Cu.ft. from Approx. Molecular Weight.
Hydrogen, H_2 ..	.0696	.005621	177.9093	Rayleigh	2.	......	2	
Oxygen, O_2.....	1.053	.08922	11.208	Rayleigh	31.76	.08926	32	.08993
Nitrogen, N_2 ...	.9673	.07829	12.773	Rayleigh	27.80	.07813	28	.07869
Air............	1.000	.08071	12.390	Rayleigh and Leduc				
Ammonia, NH_3..	.597	.04758	21.017	Leduc	16.9	.04750	17	.04778
Carbon dioxide CO_2..........	1.5291	.12269	8.1506	Rayleigh	43.75	.12295	44	.12366
Carbon monoxide, CO.....	.9672	.07807	12.8090	Leduc	27.87	.07833	28	.07869
Methane, CH_4 ..	.5576	.04470	22.349	Thomson	15.99	.04494	16	.04497
Benzole, C_6H_6...	....	Liquid						
Ethylene, C_2H_4..	.9852	.07951	12.578	Saussure	27.98	.07862	28	.07868
Ethane, C_2H_6...	1.075	.08379	11.9354	Kolbe	29.98	.08426	30	.08431
Butane, C_4H_{10}...	2.01	.16194	6.1751	Frankland	57.96	.16289	58	.16301

Computed from data reported in Smithsonian Tables, Nos. 71 and 276.

Table XXXIII
IGNITION TEMPERATURES, °F*

Substance.	Ignition Temperature.	Substance.	Ignition Temperature.
Carbon, C	752 (Sexton)	Methane, CH_4	1201 (Meyer)
Soft coal	600	Methane, CH_4	1213 (LeChatelier)
Anthracite	750	Ethane, C_2H_6	1141 (Allen)
Peat	430	Ethylene, C_2H_4	1124 (Allen)
Lignite dust	300 (Strohmeyer)	Ethylene, C_2H_4	1124 (Meyer)
Hydrogen, H_2	1077 (Olsen)	Propylene, C_3H_6	940 (Allen)
Hydrogen, H_2	1124 (Meyer)	Acetylene, C_2H_2	1038 (Allen)
Hydrogen, H_2	1031 (Le Chatelier)	Acetylene, C_2H_2	896 (Robinson)
Carbon monoxide, CO	1253 (Allen)	Propane, C_3H_8	1017
Carbon monoxide, CO	1347 (Meyer)	Alcohol, C_2H_5OH	1292
Carbon monoxide, CO	1211 (Le Chatelier)	Coal gas	1100 (Robinson)
Methane, CH_4	1212 (Allen)		

* Owing to the controlling influences of proportions and other factors on ignition temperatures the value given are of doubtful accuracy for *the* ignition temperature, at least for gases.

Table XXXIV
THE CRITICAL POINT

Substance.	Symbol.	Critical Temp.		Critical Pressures.		Critical Density Water at 4°C = 1.	Authority.	Critical vol. Cu.ft. per Lb.	Authority.
		0° C.	0° F.	Atm.	Lbs. per Sq.in.				
Hydrogen	H_2	−243.5	−390.1	20	294	.....	Olszewski		
Oxygen	O_2	−118.[1]	−180.4	50[1]	735	.65[2]	[1] Wroblewski [2] Dewar		
Nitrogen	N_2	−146.[1]	−232.8	35.[1]	515	.44[2]	[1] Olszewski [2] Wroblewski		
Ammonia	NH_3	+130.0	266.	115.	1690	.....	Dewar		
Ammonia	NH_3	+131.0	267.8	113.	1660	.....	Vincent and Chappuis		
Carbon dioxide	CO_2	+ 31.35	88.43	72.9	1070	.464	Amagat		
Carbon dioxide	CO_2	+ 30.92[1]	87.67	77.[1]	1130	.45[2]	[1] Andrews [2] Cailletet and Mathias		
Water	H_2O	+358.1	676.4	......	....	.429	Nadejdini		
Water	H_2O	+364.3	687.7	194.61	2859	.....	Batteli	26.8	Nadejdini
Water	H_2O	+365.0	689.	200.5	2944	.....	Cailletet and Colardeau	13.	Batteli
Water	H_2O	+374.	705.2	......	....	.....	Traube and Teichner		
Water	H_2O	+374.6	706.3	......	3200	.....	Holborn and Baumann		
Water	H_2O	+374.5	706.1	......	3200	.....	Marks		

TABLE XXXV

LATENT HEAT OF VAPORIZATION AT ONE ATMOSPHERE PRESSURE

Selected from Landolt, Börnstein, Meyerhoff, and Smithsonian Physical Tables.

Substance.	Symbol.	Cal. per Kg.	B.T.U. per Lb.	C.	F.	Authority.
Ammonia	NH_6	294.21	530	7.8	4.6	Regnault
	......	291.32	524.45	11.04	51.87	Regnault
	......	297.38	535	16.0	60.8	Regnault
	......	296.5	534	17	62.6	Strombeck
Water	H_2O	535.9	964.6	100	212	Andrews
	......	532.0	957.6	100	212	Schall
Benzol	C_6H_6	109.	196	0	32	Regnault
	......	132.1	238	100	212	Regnault
	......	154.5	278	210	410	Regnault
Air	......	44.02	79.3	....	....	Shearer
	......	45.4	81.7	....	....	Shearer
Oxygen	O	58.0	106.1	−188	−306.4	Shearer
	......	60.9	109.8	....	....	Estreicher
Nitrogen	N	49.83	89.6	....	....	Shearer
Carbon dioxide	CO_2	72.23	130	−25	− 13	Cailletet
	......	57.48	103.2	0	32	Matthias
	......	56.25	10 .3	0	32	Chappuis
	......	50.76	91.5	6.5	43.7	Matthias
	......	31.80	57.2	22.4	72.3	Matthias
	......	14.40	25.9	29.85	85.7	Matthias
	......	11.60	20.9	30	86	Cailletet
	......	3.72	6.7	30.82	87.4	Matthias
Alcohol, methyl	CH OH	267.48	482	64.5	148.	Wirtz
Alcohol, ethyl	C_2H_6OH	206.4	372	78	172.4	Schall
Alcohol +5% water	......	214.25	386	78.4	173.1	Brix
Decane	$C_{10}H_{22}$	60.83	109.5	159.45	319	Louguinine
Hexylene	C_6H_{12}	87.3	157.1	68	154.4	Mabery
	......	......	......	70	158	Goldstein
Octane	C_8H_{16}	71.1	128	125	257	Goldstein

TABLE XXXVI

LATENT HEATS OF FUSION

Selected from Landolt, Börnstein, Meyerhoff, and Smithsonian Physical Tables.

Substance.	Symbol.	Cal. per Kg.	B.T.U .per Lb.	C.	F.	Authority.
Aluminum	Al	239.4	432	625	1157	Pionchon
Lead	Pb	5.37	9.66	362.2	619.2	Person
Iron	Fe	6.0	10.8	1000–1050	1832–1922	Pionchon
Copper	Cu	43.0	77.4	....	....	Richards
Nickel	Ni	4.64	8.35	....	....	Pionchon
Zinc	Zn	28.1	50.5	415	779	Person
Tin	Sn	14.25	25.65	233	451.4	Person
Ammonia	NH_3	108.1	195	−75	−102	Massol
Ice-water	H_2O	79.25	142.5	0	32	Person and Regnault
	......	79.06	142.2	0	32	Regnault
	......	79.24	142.5	0	32	Desains
	......	79.91	143.9	0	32	Smith
	......	80.025	144.3	0	32	Bunsen
Benzol	C_6H_6	30.08	55.5	5.3	41.6	Fisher

TABLE XXXVII

BOILING-POINTS (AT 29.92 HG)

Selected from Landolt, Börnstein, Meyerhoff, and Smithsonian Physical Tables.

Class.	Substance.	Symbol.	Boiling-point. C.	Boiling-point. F.	Authority.
Elements	Hydrogen	H	−252.5	−412	Dewar, 1901
	Oxygen	O	−182.7	−297	Holborn, 1901
	Nitrogen	N	−194.4	−318	Olszewski
	Chlorine	Cl	− 33.6	− 28.5	Regnault
	Mercury	Hg	357	674	Crafts–Regnault
	Bromine	Br	61.1	142	Mean of Thorpe, van der Plaats
	Phosphorus	P	287	558	Schrötter, 1848
	Potassium	K	712	1372	Perman, Ruff, and Johannsen
	Sodium	Na	750	1382	Perman, Ruff, and Johannsen
	Sulphur	S	444.7	837	Rothe, 1903
	Tin	Sn	2270	4118	Greenwood
	Bismuth	Bi	1430	2607	Barus, Greenwood
	Cadmium	Cd	782	1440	Barus, 1894
	Lead	Pb	1525	2777	Greenwood
	Zinc	Zn	918	1686	Berthelot
	Antimony	Sb	1440	2622	Greenwood
	Magnesium	Mg	1120	2047	Greenwood
	Aluminum	Al	1800	3272	Greenwood
	Silver	Ag	1955	3552	Greenwood
	Copper	Cu	2310	4192	Greenwood
	Manganese	Mn	1900	3452	Greenwood
	Chromium	Cr	2200	3992	Greenwood
	Iron	Fe	2450	4442	Greenwood
Inorganic compounds	Ammonia	NH_3	− 38.5	−37.4	Regnault, 1863
	Carbon monoxide	CO	−191.5	−313	Mean of Wroblewski and Olszewski
	Carbon dioxide	CO_2	− 79.1	−110.5	Villard and Jarry
	Sulphur dioxide	SO_2	− 10.8	12.6	Regnault, 1863
	Zinc chloride	$ZnCl_2$	730	1347	Freyer and Meyer
	Air	......	−192.2	−314	Wroblewski
		......	−191.4	−312.5	Olszewski

TABLE XXXVII—*Continued*

BOILING-POINTS (AT 29.92 HG)

Selected from Landolt, Börnstein, Meyerhoff, and Smithsonian Physical Tables.

Class.	Substance.	Symbol.	Boiling-point.		Authority.
			C.	F.	
Hydrocarbon constituents of liquid and gaseous fuels	Methane	CH_4	−165	−265	Young
	Ethane	C_2H_6	− 93	−135	Ladenberg
	Propane	C_3H_8	− 45	− 49	Young, Hamlen
	Butane	C_4H_{10}	+ 1	33.8	Butlerow, Young
	Pentane	C_5H_{12}	36.3	97.3	Thorpe, Young
	Hexane	C_6H_{14}	69	156.2	Schorlemmer
	Heptane	C_7H_{16}	98.4	209.1	Thorpe, Young
	Octane	C_8H_{18}	125.5	257.9	Thorpe, Young
Paraffine series, C_nH_{2n+2}	Nonane	C_9H_{20}	150	302	Kraft
	Decane	$C_{10}H_{22}$	173	343.4	Kraft
	Undecane	$C_{11}H_{24}$	195	384	Kraft
	Dodecane	$C_{12}H_{28}$	214	417.2	Kraft
	Tridecane	$C_{13}H_{28}$	234	453.2	Kraft
	Tetradecane	$C_{14}H_{30}$	252	485.6	Kraft
	Pentadecane	$C_{15}H_{32}$	270	518	Kraft
	Hexadecane	$C_{18}H_{34}$	287	548.6	Kraft
	Heptadecane	$C_{17}H_{38}$	303	577	Kraft
	Octadecane	$C_{18}H_{38}$	317	602	Kraft
	Nonadecane	$C_{19}H_{40}$	330	626	Kraft
Ethylene series, C_2H_{2n}	Ethylene	C_2H_4	−103	−153.4	Olszewski
	Propylene	C_3H_6	− 50.2	− 58.5	Ladenburg-Krügel
	Butylene	C_4H_8	+ 1	33.8	Sieben
	Amylene	C_5H_{10}	36	96.8	Wagner
	Hexylene	C_6H_{12}	69	156.2	Wreden
	Heptylene	C_7H_{14}	96–99	205–210	Morgan
	Octylene	C_8H_{16}	122–123	251–255	Möslinger
	Nonylene	C_9H_{18}	140–142	284–288	Beilstein
	Decylene	$C_{10}H_{20}$	175	347	Beilstein
	Acetylene	C_2H_2	− 85	−121	Villard
	Methyl alcohol	CH_3OH	66	150.8	....
	Ethyl alcohol	C_2H_5OH	78	172.4	....
	Naphthas	Mixture	....	424 app.	General
	Benzines	Mixture	....	177 app.	General

TABLE XXXVIII

INTERNATIONAL ATOMIC WEIGHTS

Selected from Report of the International Committee on Atomic Weights, *Journal Amer. Chem. Soc.*, 1910.

Substance.	Symbol.	Atomic Weight, O=16.	Atomic Weight, H=1.
Aluminum	Al	27.1	26.9
Calcium	Ca	40.09	39.77
Carbon	C	12.00	11.99
Chlorine	Cl	35.46	35.19
Copper	Cu	63.57	63.07
Hydrogen	H	1.008	1.00
Iron	Fe	55.85	55.41
Lead	Pb	207.10	205.46
Magnesium	Mg	24.32	24.13
Manganese	Mn	54.93	54.49
Mercury	Hg	200.00	198.50
Nickel	Ni	58.68	58.21
Nitrogen	N	14.01	13.90
Oxygen	O	16.00	15.88
Platinum	Pt	195.00	193.40
Potassium	K	39.10	38.79
Silicon	Si	28.30	28.20
Sodium	Na	23.00	22.82
Sulphur	S	32.07	31.82
Tin	Sn	119.00	118.10
Zinc	Zn	65.37	64.88

TABLE XXXIX

MELTING OR FREEZING-POINTS (AT 29.92 HG)

Selected from Landolt, Börnstein, Meyerhoff, and Smithsonian Physical Tables.

Class.	Substance.	Symbols.	Freezing-point.		Authority.
			C.	F.	
Elements:	Hydrogen	H	−258.9	−432	Travers, 1902
	Oxygen	O	−230	−382.5	General
	Nitrogen	N	−210.5	−347	Fischer-Alt
	Chlorine	Cl	−102	−151.5	Olszewski
	Mercury	Hg	− 38.85	− 38	Vincentini and Omodei, 1888
	Bromine	Br	− 7.3	45.2	Van der Plaats, 1886
	Phosphorus	P	44.2	111.5	Helff, 1893
	Potassium	K	62.5	144.5	Holt and Sims, 1894
	Sodium	Na	97	206.5	Kurnakow and Puschin, 1902
	Sulphur	S	113.5–119.5	236–247	Depending on form of S

TABLE XXXIX—*Continued*

MELTING OR FREEZING-POINTS (AT 29.92 HG)

Selected from Landolt, Börnstein, Meyerhoff, and Smithsonian Physical Tables.

Class.	Substance.	Symbols.	Freezing-point. C.	Freezing-point. F.	Authority.
Elements:	Tin	Sn	231.5	451	Kurnakow and Puschin, 1902
	Bismuth	Bi	269.2	517	Callendar, 1899
	Cadmium	Ca	321	610	Kurnakow and Puschin, 1902
	Lead	Pb	326.9	621	Holborn and Day
	Zinc	Zn	419	787	Holborn and Day
	Antimony	Sb	624	1154	Fay and Ashley
	Magnesium	Mg	632.6	1171	Heycock and Neville, 1895
	Aluminum	Al	657.3	1217	Holborn and Day
	Silver	Ag	961	1651	Holborn and Day
	Gold	Au	1063	1947	Roberts and Austin
	Copper	Cu	1083	1892	Roberts and Austin
	Manganese	Mn	1225	2232	Day-Sosman
	Silicon	Si	1420	2592	General
	Nickel	Ni	1450	2647	Carnelley, Pictet, 1879
	Cobalt	Co	1490	2813	General
	Chromium	Cr	1505	2792	General
	Iron	Fe	1600	2912	Roberts and Austin
	Platinum	Pt	1755	3192	Mean of three
	Tungsten	W	2950	5347	Waidner–Burgess, Waterburg
Inorganic compounds	Ammonia	NH_3	−75.5	−104	Ladenburg and Krugel, 1900
	Calcium chloride	$CaCl_2$	780	1454	Ruff and Plato, 1903
	Carbon monoxide	CO	−203	−331.5	Wroblewski, Olszewski (mean)
	Carbon dioxide	CO_2	−57	70.8	General
	Sodium chloride	NaCl	820	1510	Ruff and Plato, 1903
	Sulphur dioxide	SO_2	−76	−105	Faraday, 1845
	Zinc chloride	$ZnCl_2$	262	504	Braun, 1875
	Air	.....	−1922	−314	Wroblewski, 1884
					LIQUID DENSITY
Hydrocarbon constituents of liquid and gaseous fuel Paraffine series, C_nH_{2n+2}	Ethane	C_2H_6	−171.4	−276.5	.446 at 32° F.
	Nonane	C_9H_{20}	−51	−59.8	.733 at 32° F.
	Decane	$C_{10}H_{22}$	−31	−23.8	.745 at 32° F.
	Undecane	$C_{11}H_{24}$	−26	−14.8	.756 at 32° F.
	Dodecane	$C_{12}H_{26}$	−12	10.4	.765 at 32° F.
	Tridecane	$C_{13}H_{28}$	−6	21.2	.771 at 32° F.
	Tetradecane	$C_{14}H_{30}$	+5	41	.775 at 40° F.
	Pentadecane	$C_{15}H_{32}$	10	50	.776 at 10° C.
	Hexadecane	$C_{16}H_{34}$	18	64.4	.775 at 18° C.
	Heptadecane	$C_{17}H_{36}$	22	71.6	.777 at 22° C.
	Octadecane	$C_{18}H_{38}$	28	82.4	.777 at 28° C.
	Nonadecane	$C_{19}H_{40}$	32	89.6	.777 at 32° C.
Ethylene Series, C_nH_{2n}	Ethylene	C_2H_4	−169	−272	.610
	Ethyl alcohol	C_2H_5OH	−130	−202	.806 at 32° F.

Table XL

PROPERTIES OF SATURATED STEAM

(Condensed from Marks and Davis's Steam Tables and Diagrams, 1909, by permission of the publishers, Longmans, Green & Co.)

Vacuum in inches Hg or Gauge Pressure Pounds per Sq.in.	Absolute Pressure Pounds per Sq.in.	Temperature, Fahrenheat.	Total Heat Above 32° F. In the Water, h Heat-units	Total Heat Above 32° F. In the Steam, H Heat-units	Latent Heat, $L=H-h$ Heat-units	Volume, Cu. Ft. in 1 Lb. of Steam.	Weight of 1 Cu. Ft. Steam, Pound.	Entropy of the Water.	Entropy of Evaporation.
29.74	0.0886	32	0.00	1073.4	1073.4	3294	0.000304	0.0000	2.1832
29.67	0.1217	40	8.05	1076.9	1068.9	2438	0.000410	0.0162	2.1394
29.56	0.1780	50	18.08	1081.4	1063.3	1702	0.000587	0.0361	2.0865
29.40	0.2562	60	28.08	1085.9	1057.8	1208	0.000828	0.0555	2.0358
29.18	0.3626	70	38.06	1090.3	1052.3	871	0.001148	0.0745	1.9868
28.89	0.505	80	48.03	1094.8	1046.7	636.8	0.001570	0.0932	1.9398
28.50	0.696	90	58.00	1099.2	1041.2	469.3	0.002131	0.1114	1.8944
28.00	0.946	100	67.97	1103.6	1035.6	350.8	0.002851	0.1295	1.8505
27.88	1	101.83	69.8	1104.4	1034.6	333.0	0.00300	0.1327	1.8427
25.85	2	126.15	94.0	1115.0	1021.0	173.5	0.00576	0.1749	1.7431
23.81	3	141.52	109.4	1121.6	1012.3	118.5	0.00845	0.2008	1.6840
21.78	4	153.01	120.9	1126.5	1005.7	90.5	0.01107	0.2198	1.6416
19.74	5	162.28	130.1	1130.5	1000.3	73.33	0.01364	0.2348	1.6084
17.70	6	170.06	137.9	1133.7	995.8	61.89	0.01616	0.2471	1.5814
15.67	7	176.85	144.7	1136.5	991.8	53.56	0.01867	0.2579	1.5582
13.63	8	182.86	150.8	1139.0	988.2	47.27	0.02115	0.2673	1.5380
11.60	9	188.27	156.2	1141.1	985.0	42.36	0.02361	0.2756	1.5202
9.56	10	193.22	161.1	1143.1	982.0	38.38	0.02606	0.2832	1.5042
7.52	11	197.75	165.7	1144.9	979.2	35.10	0.02849	0.2902	1.4895
5.49	12	201.96	169.9	1146.5	976.6	32.36	0.03090	0.2967	1.4760
3.45	13	205.87	173.8	1148.0	974.2	30.03	0.03330	0.3025	1.4639
1.42	14	209.55	177.5	1149.4	971.9	28.02	0.03569	0.3081	1.4523
lbs. gauge	14.70	212	180.0	1150.4	970.4	26.79	0.03732	0.3118	1.4447
0.3	15	213.0	181.0	1150.7	969.7	26.27	0.03806	0.3133	1.4416
1.3	16	216.3	184.4	1152.0	967.6	24.79	0.04042	0.3183	1.4311
2.3	17	219.4	187.5	1153.1	965.6	23.38	0.04277	0.3229	1.4215
3.3	18	222.4	190.5	1154.2	963.7	22.16	0.04512	0.3273	1.4127
4.3	19	225.2	193.4	1155.2	961.8	21.07	0.04746	0.3315	1.4045
5.3	20	228.0	196.1	1156.2	960.0	20.08	0.04980	0.3355	1.3965
6.3	21	230.6	198.8	1157.1	958.3	19.18	0.05213	0.3393	1.3887
7.3	22	233.1	201.3	1158.0	956.7	18.37	0.05445	0.3430	1.3811
8.3	23	235.5	203.8	1158.8	955.1	17.62	0.05676	0.3465	1.3739
9.3	24	237.8	206.1	1159.6	953.5	16.93	0.05907	0.3499	1.3670
10.3	25	240.1	208.4	1160.4	952.0	16.30	0.0614	0.3532	1.3604
11.3	26	242.2	210.6	1161.2	950.6	15.72	0.0636	0.3564	1.3542
12.3	27	244.4	212.7	1161.9	949.2	15.18	0.0659	0.3594	1.3483
13.3	28	246.4	214.8	1162.6	947.8	14.67	0.0682	0.3623	1.3425
14.3	29	248.4	216.8	1163.2	946.4	14.19	0.0705	0.3652	1.3367
15.3	30	250.3	218.8	1163.9	945.1	13.74	0.0728	0.3680	1.3311
16.3	31	252.2	220.7	1164.5	943.8	13.32	0.0751	0.3707	1.3257
17.3	32	254.1	222.6	1165.1	942.5	12.93	0.0773	0.3733	1.3205
18.3	33	255.8	224.4	1165.7	941.3	12.57	0.0795	0.3759	1.3155
19.3	34	257.6	226.2	1166.3	940.1	12.22	0.0818	0.3784	1.3107
20.3	35	259.3	227.9	1166.8	938.9	11.89	0.0841	0.3808	1.3060

TABLE XL—*Continued*

Gauge Pressure Pounds per Sq.in.	Absolute Pressure Pounds per Sq.in.	Temperature, Fahrenheit.	Total Heat Above 32° F. In the Water, h Heat-units	Total Heat Above 32° F. In the Steam, H Heat-units	Latent Heat, $L=H-h$ Heat-units	Volume, Cu. Ft. in 1 Lb. of Steam.	Weight of 1 Cu. Ft. Steam, Pound.	Entropy of the Water.	Entropy of Evaporation.
21.3	36	261.0	229.6	1167.3	937.7	11.58	0.0863	0.3832	1.3014
22.3	37	262.6	231.3	1167.8	936.6	11.29	0.0886	0.3855	1.2969
23.3	38	264.2	232.9	1168.4	935.5	11.01	0.0908	0.3877	1.2925
24.3	39	265.8	234.5	1168.9	934.4	10.74	0.0931	0.3899	1.2882
25.3	40	267.3	236.1	1169.4	933.3	10.49	0.0953	0.3920	1.2841
26.3	41	268.7	237.6	1169.8	932.2	10.25	0.0976	0.3941	1.2800
27.3	42	270.2	239.1	1170.3	931.2	10.02	0.0998	0.3962	1.2759
28.3	43	271.7	240.5	1170.7	930.2	9.80	0.1020	0.3982	1.2720
29.3	44	273.1	242.0	1171.2	929.2	9.59	0.1043	0.4002	1.2681
30.3	45	274.5	243.4	1171.6	928.2	9.39	0.1065	0.4021	1.2644
31.3	46	275.8	244.8	1172.0	927.2	9.20	0.1087	0.4040	1.2607
32.3	47	277.2	246.1	1172.4	926.3	9.02	0.1109	0.4059	1.2571
33.3	48	278.5	247.5	1172.8	925.3	8.84	0.1131	0.4077	1.2536
34.3	49	279.8	248.8	1173.2	924.4	8.67	0.1153	0.4095	1.2502
35.3	50	281.0	250.1	1173.6	923.5	8.51	0.1175	0.4113	1.2468
36.3	51	282.3	251.4	1174.0	922.6	8.35	0.1197	0.4130	1.2432
37.3	52	283.5	252.6	1174.3	921.7	8.20	0.1219	0.4147	1.2405
38.3	53	284.7	253.9	1174.7	920.8	8.05	0.1241	0.4164	1.2370
39.3	54	285.9	255.1	1175.0	919.9	7.91	0.1263	0.4180	1.2339
40.3	55	287.1	256.3	1175.4	919.0	7.78	0.1285	0.4196	1.2309
41.3	56	288.2	257.5	1175.7	918.2	7.65	0.1307	0.4212	1.2278
42.3	57	289.4	258.7	1176.0	917.4	7.52	0.1329	0.4227	1.2248
43.3	58	290.5	259.8	1176.4	916.5	7.40	0.1350	0.4242	1.2218
44.3	59	291.6	261.0	1176.7	915.7	7.28	0.1372	0.4257	1.2189
45.3	60	292.7	262.1	1177.0	914.9	7.17	0.1394	0.4272	1.2160
46.3	61	293.8	263.2	1177.3	914.1	7.06	0.1416	0.4287	1.2132
47.3	62	294.9	264.3	1177.6	913.3	6.95	0.1438	0.4302	1.2104
48.3	63	295.9	265.4	1177.9	912.5	6.85	0.1460	0.4316	1.2077
49.3	64	297.0	266.4	1178.2	911.8	6.75	0.1482	0.4330	1.2050
50.3	65	298.0	267.5	1178.5	911.0	6.65	0.1503	0.4344	1.2024
51.3	66	299.0	268.5	1178.8	910.2	6.56	0.1525	0.4358	1.1998
52.3	67	300.0	269.6	1179.0	909.5	6.47	0.1547	0.4371	1.1972
53.3	68	301.0	270.6	1179.3	908.7	6.38	0.1569	0.4385	1.1946
54.3	69	302.0	271.6	1179.6	908.0	6.29	0.1590	0.4398	1.1921
55.3	70	302.9	272.6	1179.8	907.2	6.20	0.1612	0.4411	1.1896
56.3	71	303.9	273.6	1180.1	906.5	6.12	0.1634	0.4422	1.1872
57.3	72	304.8	274.5	1180.4	905.8	6.04	0.1656	0.4437	1.1848
58.3	73	305.8	275.5	1180.6	905.1	5.96	0.1678	0.4449	1.1825
59.3	74	306.7	276.5	1180.9	904.4	5.89	0.1699	0.4462	1 1801
60.3	75	307.6	277.4	1181.1	903.7	5.81	0.1721	0.4474	1.1778
61.3	76	308.5	278.3	1181.4	903.0	5.74	0.1743	0.4487	1.1755
62.3	77	309.4	279.3	1181.6	902.3	5.67	0.1764	0.4499	1.1730
63.3	78	310.3	280.2	1181.8	901.7	5.60	0.1786	0.4511	1.1712
64.3	79	311.2	281.1	1182.1	901.0	5.54	0.1808	0.4523	1.1687
65.3	80	312.0	282.0	1182.3	900.3	5.47	0.1829	0.4535	1.1665
66.3	81	312.9	282.9	1182.5	899.7	5.41	0.1851	0.4546	1.1644
67.3	82	313.8	283.8	1182.8	899.0	5.34	0.1873	0.4557	1.1623
68.3	83	314.6	284.6	1183.0	898.4	5.28	0.1894	0.4568	1.1602

TABLE XL—*Continued*

Gauge Pressure Pounds per Sq.in.	Absolute Pressure Pounds per Sq.in.	Temperature, Fahrenheit.	Total Heat Above 32° F. In the Water, h Heat-units	Total Heat Above 32° F. In the Steam, H Heat-units	Latent Heat, $L=H-h$ Heat-units	Volume, Cu. Ft. in 1 Lb. of Steam.	Weight of 1 Cu. Ft. Steam, Pound.	Entropy of the Water.	Entropy of Evaporation.
69.3	84	315.4	285.5	1183.2	897.7	5.22	0.1915	0.4579	1.1581
70.3	85	316.3	286.3	1183.4	897.1	5.16	0.1937	0.4590	1.1561
71.3	86	317.1	287.2	1183.6	896.4	5.10	0.1959	0.4601	1.1540
72.3	87	317.9	288.0	1183.8	895.8	5.05	0.1980	0.4612	1.1520
73.3	88	318.7	288.9	1184.0	895.2	5.00	0.2001	0.4623	1.1500
74.3	89	319.5	289.7	1184.2	894.6	4.94	0.2023	0.4633	1.1481
75.3	90	320.3	290.5	1184.4	893.9	4.89	0.2044	0.4644	1.1461
76.3	91	321.1	291.3	1184.6	893.3	4.84	0.2065	0.4654	1.1442
77.3	92	321.8	292.1	1184.8	892.7	4.79	0.2087	0.4664	1.1423
78.3	93	322.6	292.9	1185.0	892.1	4.74	0.2109	0.4674	1.1404
79.3	94	323.4	293.7	1185.2	891.5	4.69	0.2130	0.4684	1.1385
80.3	95	324.1	294.5	1185.4	890.9	4.65	0.2151	0.4694	1.1367
81.3	96	324.9	295.3	1185.6	890.3	4.60	0.2172	0.4704	1.1348
82.3	97	325.6	296.1	1185.8	889.7	4.56	0.2193	0.4714	1.1330
83.3	98	326.4	296.8	1186.0	889.2	4.51	0.2215	0.4724	1.1312
84.3	99	327.1	297.6	1186.2	888.6	4.47	0.2237	0.4733	1.1295
85.3	100	327.8	298.3	1186.3	888.0	4.429	0.2258	0.4743	1.1277
87.3	102	329.3	299.8	1186.7	886.9	4.347	0.2300	0.4762	1.1242
89.3	104	330.7	301.3	1187.0	885.8	4.268	0.2343	0.4780	1.1208
91.3	106	332.0	302.7	1187.4	884.7	4.192	0.2336	0.4798	1.1174
93.3	108	333.4	304.1	1187.7	883.6	4.118	0.2429	0.4816	1.1141
95.3	110	334.8	305.5	1188.0	882.5	4.047	0.2472	0.4834	1.1108
97.3	112	336.1	306.9	1188.4	881.4	3.978	0.2514	0.4852	1.1076
99.3	114	337.4	308.3	1188.7	880.4	3.912	0.2556	0.4869	1.1045
101.3	116	338.7	309.6	1189.0	879.3	3.848	0.2599	0.4886	1.1014
103.3	118	340.0	311.0	1189.3	878.3	3.786	0.2641	0.4903	1.0984
105.3	120	341.3	312.3	1189.6	877.2	3.726	0.2683	0.4919	1.0954
107.3	122	342.5	313.6	1189.8	876.2	3.668	0.2726	0.4935	1.0924
109.3	124	343.8	314.9	1190.1	875.2	3.611	0.2769	0.4951	1.0895
111.3	126	345.0	316.2	1190.4	874.2	3.556	0.2812	0.4967	1.0865
113.3	128	346.2	317.4	1190.7	873.3	3.504	0.2854	0.4982	1.0837
115.3	130	347.4	318.6	1191.0	872.3	3.452	0.2897	0.4998	1.0809
117.3	132	348.5	319.9	1191.2	871.3	3.402	0.2939	0.5013	1.0782
119.3	134	349.7	321.1	1191.5	870.4	3.354	0.2981	0.5028	1.0755
121.3	136	350.8	322.3	1191.7	869.4	3.308	0.3023	0.5043	1.0728
123.3	138	352.0	323.4	1192.0	868.5	3.263	0.3065	0.5057	1.0702
125.3	140	353.1	324.6	1192.2	867.6	3.219	0.3107	0.5072	1.0675
127.3	142	354.2	325.8	1192.5	866.7	3.175	0.3150	0.5086	1.0649
129.3	144	355.3	326.9	1192.7	865.8	3.133	0.3192	0.5100	1.0624
131.3	146	356.3	328.0	1192.9	864.9	3.092	0.3234	0.5114	1.0599
133.3	148	357.4	329.1	1193.2	864.0	3.052	0.3276	0.5128	1.0574
135.3	150	358.5	330.2	1193.4	863.2	3.012	0.3320	0.5142	1.0550
137.3	152	359.5	331.4	1193.6	862.3	2.974	0.3362	0.5155	1.0525
139.3	154	360.5	332.4	1193.8	861.4	2.938	0.3404	0.5169	1.0501
141.3	156	361.6	333.5	1194.1	860.6	2.902	0.3446	0.5182	1.0477
143.3	158	362.6	334.6	1194.3	859.7	2.868	0.3488	0.5195	1.0454
145.3	160	363.6	335.6	1194.5	858.8	2.834	0.3529	0.5208	1.0431
147.3	162	364.6	336.7	1194.7	858.0	2.801	0.3570	0.5220	1.0409

TABLE XL—*Continued*

Gauge Pressure Pounds per Sq.in.	Absolute Pressure Pounds per Sq.in.	Temperature, Fahrenheat.	Total Heat Above 32° F. In the Water, h Heat-units	In the Steam, H Heat-units	Latent Heat, $L=H-h$ Heat-units	Volume, Cu. Ft. in 1 Lb. of Steam.	Weight of 1 Cu. Ft. Steam, Pound.	Entropy of the Water.	Entropy of Evaporation.
149.3	164	365.6	337.7	1194.9	857.2	2.769	0.3612	0.5233	1.0387
151.3	166	366.5	338.7	1195.1	856.4	2.737	0.3654	0.5245	1.0365
153.3	168	367.5	339.7	1195.3	855.5	2.706	0.3696	0.5257	1.0343
155.3	170	368.5	340.7	1195.4	854.7	2.675	0.3738	0.5269	1.0321
157.3	172	369.4	341.7	1195.6	853.9	2.645	0.3780	0.5281	1.0300
159.3	174	370.4	342.7	1195.8	853.1	2.616	0.3822	0.5293	1.0278
161.3	176	371.3	343.7	1196.0	852.3	2.588	0.3864	0.5305	1.0257
163.3	178	372.2	344.7	1196.2	851.5	2.560	0.3906	0.5317	1.0235
165.3	180	373.1	345.6	1196.4	850.8	2.533	0.3948	0.5328	1.0215
167.3	182	374.0	346.6	1196.6	850.0	2.507	0.3989	0.5339	1.0195
169.3	184	374.9	347.6	1196.8	849.2	2.481	0.4031	0.5351	1.0174
171.3	186	375.8	348.5	1196.9	848.4	2.455	0.4073	0.5362	1.0154
173.3	188	376.7	349.4	1197.1	847.7	2.430	0.4115	0.5373	1.0134
175.3	190	377.6	350.4	1197.3	846.9	2.406	0.4157	0.5384	1.0114
177.3	192	378.5	351.3	1197.4	846.1	2.381	0.4199	0.5395	1.0095
179.3	194	379.3	352.2	1197.6	845.4	2.358	0.4241	0.5405	1.0076
181.3	196	380.2	353.1	1197.8	844.7	2.335	0.4283	0.5416	1.0056
183.3	198	381.0	354.0	1197.9	843.9	2.312	0.4325	0.5426	1.0038
185.3	200	381.9	354.9	1198.1	843.2	2.290	0.437	0.5437	1.0019
190.3	205	384.0	357.1	1198.5	841.4	2.237	0.447	0.5463	0.9973
195.3	210	386.0	359.2	1198.8	839.6	2.187	0.457	0.5488	0.9928
200.3	215	388.0	361.4	1199.2	837.9	2.138	0.468	0.5513	0.9885
205.3	220	389.9	363.4	1199.6	836.2	2.091	0.478	0.5538	0.9841
210.3	225	391.9	365.5	1199.9	834.4	2.046	0.489	0.5562	0.9799
215.3	230	393.8	367.5	1200.2	832.8	2.004	0.499	0.5586	0.9758
220.3	235	395.6	369.4	1200.6	831.1	1.964	0.509	0.5610	0.9717
225.3	240	397.4	371.4	1200.9	829.5	1.924	0.520	0.5633	0.9676
230.3	245	399.3	373.3	1201.2	827.9	1.887	0.530	0.5655	0.9638
235.3	250	401.1	375.2	1201.5	826.3	1.850	0.541	0.5676	0.9600
245.3	260	404.5	378.9	1202.1	823.1	1.782	9.561	0.5719	0.9525
255.3	270	407.9	382.5	1202.6	820.1	1.718	0.582	0.5760	0.9454
265.3	280	411.2	386.0	1203.1	817.1	1.658	0.603	0.5800	0.9385
275.3	290	414.4	389.4	1203.6	814.2	1.602	0.624	0.5840	0.9316
285.3	300	417.5	392.7	1204.1	811.3	1.551	0.645	0.5878	0.9251
295.3	310	420.5	395.9	1204.5	808.5	1.502	0.666	0.5915	0.9187
305.3	320	423.4	399.1	1204.9	805.8	1.456	0.687	0.5951	0.9125
315.3	330	426.3	402.2	1205.3	803.1	1.413	0.708	0.5986	0.9065
325.3	340	429.1	405.3	1205.7	800.4	1.372	0.729	0.6020	0.9006
335.3	350	431.9	408.2	1206.1	797.8	1.334	0.750	0.6053	0.8949
345.3	360	434.6	411.2	1206.4	795.3	1.298	0.770	0.6085	0.8894
355.3	370	437.2	414.0	1206.8	792.8	1.264	0.791	0.6116	0.8840
365.3	380	439.8	416.8	1207.1	790.3	1.231	0.812	0.6147	0.8788
375.3	390	442.3	419.5	1207.4	787.9	1.200	0.833	0.6178	0.8737
385.3	400	444.8	422	1208	786	1.17	0.86	0.621	0.868
435.3	450	456.5	435	1209	774	1.04	0.96	0.635	0.844
485.3	500	467.3	448	1210	762	0.93	1.08	0.648	0.822
535.3	550	477.3	459	1210	751	0.83	1.20	0.659	0.801
585.3	600	486.6	469	1210	741	0.76	1.32	0.670	0.783

TABLE XLI

PROPERTIES OF SUPERHEATED STEAM

(Condensed from Marks and Davis's Steam Tables and Diagrams)

v = specific volume in cubic feet per pound, h = total heat, from water at 32° F. in B.T.U. per pound, n = entropy, from water at 32°.

Pressure Absolute, Pounds per Sq.in.	Temp. Sat. Steam.	Degrees of Superheat.									
		0	20	50	100	150	200	250	300	400	500
20	228.0	v 20.08	20.73	21.69	23.25	24.80	26.33	27.85	29.37	32.39	35.40
		h 1156.2	1165.7	1179.9	1203.5	1227.1	1250.6	1274.1	1297.6	1344.8	1392.2
		n 1.7320	1.7456	1.7652	1.7961	1.8251	1.8524	1.8781	1.9026	1.9479	1.9893
40	267.3	v 10.49	10.83	11.33	12.13	12.93	13.70	14.48	15.25	16.78	18.30
		h 1169.4	1179.3	1194.0	1218.4	1242.4	1266.4	1290.3	1314.1	1361.6	1409.3
		n 1.6761	1.6895	1.7089	1.7392	1.7674	1.7940	1.8189	1.8427	1.8867	1.9271
60	292.7	v 7.17	7.40	7.75	8.30	8.84	9.36	9.89	10.41	11.43	12.45
		h 1177.0	1187.3	1202.6	1227.6	1252.1	1276.4	1300.4	1324.3	1372.2	1420.0
		n 1.6432	1.6568	1.6761	1.7062	1.7342	1.7603	1.7849	1.8081	1.8511	1.8908
80	312.0	v 5.47	5.65	5.92	6.34	6.75	7.17	7.56	7.95	8.72	9.49
		h 1182.3	1193.0	1208.8	1234.3	1259.0	1283.6	1307.8	1331.9	1379.8	1427.9
		n 1.6200	1.6338	1.6532	1.6833	1.7110	1.7368	1.7612	1.7840	1.8265	1.8658
100	327.8	v 4.43	4.58	4.79	5.14	5.47	5.80	6.12	6.44	7.07	7.69
		h 1186.3	1197.5	1213.8	1239.7	1264.7	1289.4	1313.6	1337.8	1385.9	1434.1
		n 1.6020	1.6160	1.6358	1.6658	1.6933	1.7188	1.7428	1.7656	1.8079	1.8468
120	341.3	v 3.73	3.85	4.04	4.33	4.62	4.89	5.17	5.44	5.96	6.48
		h 1189.6	1201.1	1217.9	1244.1	1269.3	1294.1	1318.4	1342.7	1391.0	1439.4
		n 1.5873	1.6016	1.6216	1.6517	1.6789	1.7041	1.7280	1.7505	1.7924	1.8311
140	353.1	v 3.22	3.32	3.49	3.75	4.00	4.24	4.48	4.71	5.16	5.61
		h 1192.2	1204.3	1221.4	1248.0	1273.3	1298.2	1322.6	1346.9	1395.4	1443.8
		n 1.5747	1.5894	1.6096	1.6395	1.6666	1.6916	1.7152	1.7376	1.7792	1.8177
160	363.6	v 2.83	2.93	3.07	3.30	3.53	3.74	3.95	4.15	4.56	4.95
		h 1194.5	1207.0	1224.5	1251.3	1276.8	1301.7	1326.2	1350.6	1399.3	1447.9
		n 1.5639	1.5789	1.5993	1.6292	1.6561	1.6810	1.7043	1.7266	1.7680	1.8063
180	373.1	v 2.53	2.62	2.75	2.96	3.16	3.35	3.54	3.72	4.09	4.44
		h 1196.4	1209.4	1227.2	1254.3	1279.9	1304.8	1329.5	1253.9	1402.7	1451.4
		n 1.5543	1.5697	1.5904	1.6201	1.6468	1.6716	1.6948	1.7169	1.7581	1.7962
200	381.9	v 2.29	2.37	2.49	2.68	2.86	3.04	3.21	3.38	3.71	4.03
		h 1198.1	1211.6	1229.8	1257.1	1282.6	1307.7	1332.4	1357.0	1405.9	1454.7
		n 1.5456	1.5614	1.5823	1.6120	1.6385	1.6632	1.6862	1.7082	1.7493	1.7872
220	389.9	v 2.09	2.16	2.28	2.45	2.62	2.78	2.94	3.10	3.40	3.69
		h 1199.6	1213.6	1232.2	1259.6	1285.2	1310.3	1335.1	1359.8	1408.8	1457.7
		n 1.5379	1.5541	1.5753	1.6049	1.6312	1.6558	1.6787	1.7005	1.7415	1.7792
240	397.4	v 1.92	1.99	2.09	2.26	2.42	2.57	2.71	2.85	3.13	3.40
		h 1200.9	1215.4	1234.3	1261.9	1287.6	1312.8	1337.6	1362.3	1411.5	1460.5
		n 1.5309	1.5476	1.5690	1.5985	1.6246	1.6492	1.6720	1.6937	1.7344	1.7721
260	404.5	v 1.78	1.84	1.94	2.10	2.24	2.39	2.52	2.65	2.91	3.16
		h 1202.1	1217.1	1236.4	1264.1	1289.9	1315.1	1340.0	1364.7	1414.0	1463.2
		n 1.5244	1.5416	1.5631	1.5926	1.6186	1.6430	1.6658	1.6874	1.7280	1.7655
280	411.2	v 1.66	1.72	1.81	1.95	2.09	2.22	2.35	2.48	2.72	2.95
		h 1203.1	1218.7	1238.4	1266.2	1291.9	1317.2	1342.2	1367.0	1416.4	1465.7
		n 1.5185	1.5362	1.5580	1.5873	1.6133	1.6375	1.6603	1.6818	1.7223	1.7597
300	417.5	v 1.55	1.60	1.69	1.83	1.96	2.09	2.21	2.33	2.55	2.77
		h 1204.1	1220.2	1240.3	1268.2	1294.0	1319.3	1344.3	1369.2	1418.6	1468.0
		n 1.5129	1.5310	1.5530	1.5824	1.6082	1.6323	1.6550	1.6765	1.7168	1.7541
350	431.9	v 1.33	1.38	1.46	1.58	1.70	1.81	1.92	2.02	2.22	2.41
		h 1206.1	1223.9	1244.6	1272.7	1298.7	1324.1	1349.3	1374.3	1424.0	1473.7
		n 1.5002	1.5199	1.5423	1.5715	1.5971	1.6210	1.6436	1.6650	1.7052	1.7422
400	444.8	v 1.17	1.21	1.28	1.40	1.50	1.60	1.70	1.79	1.97	2.14
		h 1207.7	1227.2	1248.6	1276.9	1303.0	1328.6	1353.9	1379.1	1429.0	1478.9
		n 1.4894	1.5107	1.5336	1.5625	1.5880	1.6117	1.6342	1.6554	1.6955	1.7323
450	456.5	v 1.04	1.08	1.14	1.25	1.35	1.44	1.53	1.61	1.77	1.93
		h 1209	1231	1252	1281	1307	1333	1358	1383	1434	1484
		n 1.479	1.502	1.526	1.554	1.580	1.603	1.626	1.647	1.687	1.723
500	467.3	v 0.93	0.97	1.03	1.13	1.22	1.31	1.39	1.47	1.62	1.76
		h 1210	1233	1256	1285	1311	1337	1362	1388	1438	1489
		n 1.470	1.496	1.519	1.548	1.573	1.597	1.619	1.640	1.679	1.715

TABLE XLII

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat. Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
420	−40	9.85	−4.85	−74	603.5	529.5	25.72	.0388	.02365	42.3	45.18	558.32	.1624	1.437
421	−39	10.1	−4.60	−73.2	602.75	529.55	24.80	.0403	.02368	42.27	45.34	557.41	.1600	1.432
422	−38	10.33	−4.37	−72.2	602.05	529.85	24.00	.0417	.0237	42.24	45.50	556.55	.1580	1.427
423	−37	10.6	−4.10	−71.2	601.4	530.2	23.30	.0429	.02371	42.21	45.68	555.72	.1556	1.422
424	−36	10.9	−3.80	−70.2	600.75	530.55	22.68	.0441	.02372	42.18	45.76	554.99	.1532	1.417
425	−35	11.2	−3.50	−69.2	600.05	530.85	22.10	.0452	.02373	42.15	46.02	554.03	.1508	1.412
426	−34	11.6	−3.10	−68.2	599.4	531.2	21.46	.0466	.02374	42.12	46.20	553.2	.1486	1.407
427	−33	12	−2.7	−67.2	598.7	531.5	20.88	.0480	.02375	42.09	46.36	552.34	.1462	1.402
428	−32	12.3	−2.4	−66.3	598	531.7	20.36	.0491	.02377	42.06	46.54	551.46	.1440	1.397
429	−31	12.7	−2.0	−65.3	597.3	532	19.84	.0504	.02378	42.03	46.70	550.6	.1414	1.392
430	−30	13.1	−1.6	−64.4	596.6	532.2	19.36	.0517	.02381	42.00	46.88	549.72	.1393	1.387
431	−29	13.5	−1.2	−63.4	595.9	532.5	18.86	.0530	.02383	41.96	47.04	548.86	.1368	1.382
432	−28	14	−0.7	−62.4	595.05	532.55	18.38	.0544	.02384	41.93	47.18	547.87	.1344	1.378
433	−27	14.4	−0.3	−61.4	594.4	533	17.92	.0559	.02386	41.90	47.34	547.06	.1320	1.373
434	−26	14.8	+0.1	−60.3	593.7	533.4	17.46	.0573	.02388	41.87	47.49	546.21	.1300	1.368
435	−25	15.25	0.55	−59.3	592.9	533.6	17.02	.0587	.02390	41.84	47.64	545.26	.1272	1.363
436	−24	15.7	1.00	−58.2	592.05	533.75	16.57	.0603	.02391	41.81	47.78	544.27	.1232	1.358
437	−23	16.2	1.5	−57.2	591.35	534.15	16.12	.0618	.02393	41.78	47.92	543.43	.1228	1.354
438	−22	16.68	2.0	−56.2	590.6	534.4	15.70	.0637	.02396	41.74	48.06	542.54	.1206	1.349
439	−21	17.15	2.35	−55.2	589.8	534.6	15.28	.0654	.02398	41.71	48.20	541.6	.1184	1.344
440	−20	17.60	2.90	−54.2	589	534.8	14.86	.0676	.02400	41.68	48.32	540.68	.1160	1.340
441	−19	18.1	3.4	−53.1	588.4	535.3	14.54	.0686	.02401	41.65	48.46	539.94	.1138	1.335
442	−18	18.6	3.9	−52.1	587.7	535.6	14.05	.0717	.02403	41.61	48.58	539.12	.1116	1.330
443	−17	19	4.4	−51.1	587	535.9	13.70	.0730	.02405	41.57	48.71	538.29	.1092	1.325
444	−16	19.6	4.9	−50.1	586.3	536.2	13.34	.0742	.02407	41.54	48.83	537.47	.1068	1.320
445	−15	20.2	5.5	−49.0	585.6	536.6	13.02	.0764	.02409	41.51	48.96	536.64	.1048	1.316
446	−14	20.8	6.1	−48.0	584.9	536.9	12.70	.0787	.02411	41.47	49.08	535.82	.1022	1.311

TABLE XLII—*Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat. Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
447	−13	21.4	6.7	−47.0	584.2	537.2	12.50	.0800	.02413	41.44	49.20	535.00	.1000	1.307
448	−12	22	7.3	−46.0	583.5	537.5	12.12	.0820	.02415	41.41	49.31	534.19	.0978	1.302
449	−11	22.6	7.9	−44.9	582.8	537.9	11.84	.0844	.02417	41.37	49.42	533.38	.0956	1.298
450	−10	23.2	8.5	−43.9	582.05	538.15	11.58	.0862	.02419	41.34	49.54	532.51	.0930	1.293
451	− 9	23.8	9.1	−43.0	581.3	538.3	11.32	.0880	.02421	41.30	49.64	531.66	.0910	1.289
452	− 8	24.5	9.8	−42.0	580.65	538.65	11.06	.0900	.02423	41.27	49.75	530.90	.0888	1.284
453	− 7	25.1	10.4	−41.0	579.9	538.9	10.82	.0920	.02426	41.23	49.86	530.04	.0864	1.280
454	− 6	25.7	11.0	−40.0	579.2	539.2	10.58	.0940	.02427	41.20	49.96	529.24	.0840	1.275
455	− 5	26.4	11.7	−38.9	578.4	539.5	10.34	.0970	.02430	41.16	50.08	528.32	.0832	1.271
456	− 4	27	12.3	−37.8	577.6	539.8	10.12	.0990	.02432	41.12	50.18	527.42	.0796	1.266
457	− 3	27.7	13.0	−36.8	576.9	540.1	9.9	.101	.02433	41.09	50.28	526.62	.0772	1.262
458	− 2	28.4	13.7	−35.8	576.05	540.25	9.66	.103	.02436	41.05	50.38	525.67	.0750	1.257
459	− 1	29.1	14.4	−34.8	575.3	540.5	9.44	.106	.02439	41.01	50.48	524.82	.0728	1.253
460	0	29.7	15.0	−33.8	574.6	540.8	9.24	.108	.02440	40.98	50.58	524.02	.0708	1.249
461	1	30.5	15.8	−32.8	574	541.2	9.00	.111	.02442	40.94	50.68	523.32	.0682	1.244
462	2	31.2	16.5	−31.8	573.2	541.4	8.80	.114	.02445	40.90	50.78	522.42	.0660	1.240
463	3	31.9	17.2	−30.7	572.4	541.7	8.60	.116	.02446	40.87	50.87	521.53	.0636	1.236
464	4	32.7	18.0	−29.6	571.6	541.95	8.40	.119	.02448	40.83	50.96	520.64	.0612	1.231
465	5	33.5	18.8	−28.6	570.8	542.2	8.22	.122	.02450	40.79	51.05	519.75	.0595	1.227
466	6	34.3	19.6	−27.6	570	542.4	8.04	.124	.02454	40.75	51.14	518.86	.0572	1.222
467	7	35.1	20.4	−26.6	569.2	542.6	7.86	.127	.02457	40.71	51.22	517.98	.0550	1.218
468	8	36	21.3	−25.6	568.4	542.8	7.70	.130	.02459	40.67	51.31	517.09	.0526	1.214
469	9	36.9	22.2	−24.5	567.6	543.1	7.54	.132	.02460	40.64	51.40	516.20	.0504	1.210
470	10	37.8	23.1	−23.5	566.8	543.3	7.38	.136	.02463	40.60	51.48	515.32	.0486	1.205
471	11	38.7	24.0	−22.4	566	543.6	7.21	.139	.02466	40.56	51.56	514.44	.0460	1.201
472	12	39.7	25	−21.4	565.2	543.8	7.05	.142	.02468	40.52	51.64	513.56	.0440	1.197
473	13	40.6	25.9	−20.4	564.3	543.9	6.90	.145	.02469	40.48	51.72	512.58	.0412	1.193

TABLE XLII — *Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
474	14	41.6	26.9	−19.3	563.5	544.2	6.75	.148	.02472	40.44	51.80	511.70	.0396	1.188
475	15	42.6	27.9	−18.2	562.6	544.4	6.60	.152	.02475	40.40	51.88	510.72	.0372	1.184
476	16	43.6	28.9	−17.2	561.8	544.6	6.45	.155	.02478	40.36	51.96	509.84	.0350	1.180
477	17	44.6	29.9	−16.2	560.9	544.7	6.32	.158	.02480	40.32	52.02	508.88	.0328	1.176
478	18	45.6	30.9	−15.1	560.1	545	6.18	.162	.02483	40.28	52.10	508.00	.0306	1.172
479	19	46.6	31.9	−14.0	559.2	545.2	6.04	.166	.02485	40.24	52.18	507.02	.0284	1.167
480	20	47.7	33.0	−13.0	558.4	545.4	5.90	.169	.02487	40.20	52.25	506.15	.0262	1.163
481	21	48.7	34.0	−12.0	557.6	545.6	5.78	.173	.02489	40.16	52.32	505.28	.0240	1.159
482	22	49.7	35.0	−11.0	556.8	545.8	5.66	.177	.02493	40.11	52.39	504.41	.0212	1.155
483	23	50.8	36.1	− 9.9	556	546.1	5.54	.180	.02495	40.07	52.46	503.54	.0196	1.151
484	24	51.9	37.2	− 8.9	555.1	546.2	5.43	.184	.02498	40.03	52.53	502.57	.0173	1.147
485	25	53	38.3	− 7.8	554.3	546.5	5.32	.188	.02500	39.99	52.60	501.70	.0152	1.143
486	26	54.1	39.4	− 6.7	553.5	546.8	5.22	.192	.02503	39.95	52.66	500.84	.0128	1.138
487	27	55.3	40.6	− 5.6	552.6	547	5.12	.195	.02506	39.90	52.73	499.87	.0106	1.134
488	28	56.5	41.8	− 4.6	551.8	547.2	5.02	.199	.02509	39.86	52.80	499.00	.0084	1.130
489	29	57.8	43.1	− 3.5	550.9	547.4	4.93	.203	.02511	39.82	52.86	498.04	.0062	1.126
490	30	59.1	44.4	− 2.5	550	547.5	4.83	.207	.02513	39.78	52.92	497.08	.0040	1.122
491	31	60.3	45.6	− 1.5	549.1	547.6	4.74	.211	.02516	39.73	52.98	496.12	.0020	1.118
492	32	61.6	46.9	− 0.4	548.2	547.8	4.66	.215	.02518	39.69	53.04	495.16	.0	1.114
493	33	62.9	48.2	+ 0.7	547.3	548	4.57	.219	.02522	39.65	53.10	494.20	.0024	1.110
494	34	64.2	49.5	+ 1.8	546.4	548.2	4.48	.223	.02525	39.60	53.16	493.24	.0046	1.106
495	35	65.6	50.9	2.8	545.5	548.3	4.40	.227	.02527	39.56	53.22	492.28	.0072	1.102
496	36	67.0	52.3	4.0	544.6	548.6	4.31	.232	.02530	39.52	53.28	491.32	.0090	1.098
497	37	68.4	53.7	+ 5.0	543.6	548.6	4.23	.236	.02533	39.47	53.34	490.26	.0112	1.094
498	38	69.8	55.1	6.1	542.6	548.7	4.14	.242	.02536	39.43	53.40	489.20	.0134	1.090
499	39	71.3	56.6	7.2	541.6	548.8	4.06	.246	.02539	39.38	53.46	488.14	.0156	1.086
500	40	72.8	58.1	8.3	540.6	548.9	3.98	.251	.02542	39.34	53.51	487.14	.0176	1.082

TABLE XLII — *Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
501	41	74.2	59.5	9.4	539.5	548.9	3.91	.256	.02544	39.29	53.56	485.94	.0200	1.078
502	42	75.7	61.0	10.4	538.5	548.9	3.84	.260	.02548	39.25	53.61	484.89	.0220	1.074
503	43	77.2	62.5	11.5	537.5	549.1	3.77	.265	.02551	39.20	53.66	483.89	.0242	1.070
504	44	78.6	63.9	12.6	536.6	549.2	3.70	.270	.02554	39.16	53.71	482.89	.0264	1.066
505	45	80.2	65.5	13.7	535.6	549.3	3.64	.274	.02557	39.11	53.76	481.84	.0284	1.062
506	46	81.9	67.2	14.8	534.6	549.4	3.57	.280	.02559	39.07	53.81	480.79	.0306	1.058
507	47	83.6	68.9	15.9	533.6	549.5	3.51	.285	.02562	39.02	53.85	479.75	.0328	1.054
508	48	85.2	70.5	17.0	532.6	549.6	3.44	.291	.02564	38.98	53.90	478.70	.0348	1.050
509	49	87.0	72.3	18.1	531.6	549.7	3.38	.296	.02567	38.93	53.94	477.66	.0368	1.045
510	50	88.7	74	19.2	530.6	549.8	3.32	.301	.02570	38.89	53.98	476.62	.0390	1.042
511	51	90.5	75.8	20.5	529.6	550.1	3.26	.307	.02574	38.84	54.01	475.59	.0407	1.038
512	52	92.3	77.6	21.6	528.6	550.2	3.21	.312	.02577	38.80	54.04	474.56	.0432	1.033
513	53	94.1	79.4	22.7	527.6	550.3	3.15	.317	.02580	38.75	54.08	473.52	.0452	1.029
514	54	96	81.3	23.8	526.6	550.4	3.08	.325	.02583	38.70	54.11	472.49	.0472	1.025
515	55	97.9	83.2	25.0	525.6	550.6	3.03	.331	.02586	38.65	54.14	471.46	.0496	1.021
516	56	99.9	85.2	26.0	524.6	550.6	2 97	.337	.02590	38.60	54.17	470.43	.0512	1.017
517	57	101.8	87.1	27.1	523.6	550.7	2.91	.344	.02594	38.55	54.20	469.40	.0538	1.013
518	58	103.8	89.1	28.2	522.6	550.8	2.86	.350	.02597	38.50	54.23	468.37	.0560	1.009
519	59	105.8	91.1	29.3	521.6	550.9	2.80	.357	.02600	38.45	54.25	467.35	.0580	1.005
520	60	107.8	93.1	30.4	520.6	551.0	2.77	.361	.02604	38.40	54.28	466.32	.0601	1.001
521	61	109.6	94.9	31.5	519.5	551.1	2.72	.367	.02607	38.35	54.30	465.25	.0624	.998
522	62	111.5	96.8	32.6	518.5	551.1	2.67	.375	.02610	38.30	54.32	464.18	.0645	.994
523	63	113.5	98.8	33.7	517.5	551.2	2.63	.380	.02614	38.25	54.34	463.16	.0666	.990
524	64	115.5	100.8	34.8	516.4	551.2	2.58	.387	.02618	38.20	54.35	462.10	.0688	.986
525	65	117.5	102.8	35.9	515.4	551.3	2.53	.397	.02621	38.16	54.37	461.03	.0706	.982
526	66	119.6	104.9	37.0	514.3	551.3	2.49	.401	.02624	38.11	54.38	459.97	.0728	.978
527	67	121.8	107.1	33.1	513.3	551.4	2.44	.410	.02628	38.06	54.39	458.91	.0750	.974

TABLE XLII — *Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
528	68	123.9	109.2	39.2	512.2	551.4	2.40	.417	.02631	38.01	54.40	457.80	.0770	.970
529	69	126.1	111.4	40.4	511.1	551.5	2.35	.426	.02635	37.96	54.41	456.74	.0792	.967
530	70	128.4	113.7	41.5	510.1	551.6	2.31	.432	.02638	37.91	54.42	455.68	.0809	.963
531	71	130.8	116.1	42.6	509.0	551.6	2.27	.440	.02642	37.86	54.42	454.63	.0832	.959
532	72	133.2	118.5	43.6	508	551.6	2.23	.448	.02645	37.81	54.43	453.57	.0852	.955
533	73	135.6	120.9	44.8	506.9	551.7	2.20	.455	.02649	37.76	54.43	452.52	.0872	.951
534	74	138	123.3	45.8	505.9	551.7	2.16	.463	.02652	37.72	54.44	451.46	.0892	.948
535	75	140.5	125.8	47.0	504.8	551.8	2.12	.472	.02654	37.67	54.44	450.36	.0913	.944
536	76	143	128.3	48.0	503.7	551.7	2.08	.481	.02658	37.62	54.44	449.26	.0933	.940
537	77	145.5	130.8	49.1	502.6	551.7	2.05	.488	.02661	37.57	54.44	448.16	.0954	.936
538	78	148.1	133.4	50.2	501.5	551.7	2.01	.497	.02665	37.52	54.43	447.07	.0976	.932
539	79	150.7	136.0	51.3	500.4	551.7	1.98	.505	.02668	37.47	54.43	445.97	.0996	.928
540	80	153.2	138.5	52.4	499.3	551.7	1.94	.515	.02672	37.42	54.42	444.88	.1016	.925
541	81	155.6	140.9	53.5	498.1	551.6	1.91	.524	.02675	37.37	54.41	443.69	.1038	.921
542	82	158.3	143.6	54.6	496.9	551.5	1.88	.532	.02679	37.32	54.41	442.49	.1058	.917
543	83	161.0	146.3	55.8	495.7	551.5	1.85	.541	.02683	37.26	54.40	441.30	.1080	.913
544	84	163.8	149.1	56.9	494.6	551.5	1.82	.550	.02688	37.21	54.39	440.21	.1100	.910
545	85	166.8	152.1	58.0	493.4	551.5	1.79	.559	.02690	37.15	54.38	439.02	.1122	.906
546	86	169.2	154.5	59.2	492.3	551.5	1.76	.568	.02695	37.10	54.36	437.94	.1142	.902
547	87	172.2	157.5	60.3	491.1	551.5	1.72	.580	.02699	37.05	54.35	436.75	.1164	.899
548	88	175.1	160.4	61.5	490	551.5	1.70	.588	.02703	37.00	54.33	435.67	.1184	.895
549	89	178	163.3	62.7	488.8	551.5	1.68	.595	.02706	36.94	54.32	434.48	.1206	.891
550	90	181	166.3	63.9	487.7	551.6	1.65	.606	.02710	36.89	54.30	433.40	.1227	.887
551	91	183.8	169.1	65.2	486.5	551.7	1.62	.615	.02715	36.83	54.28	432.22	.1248	.883
552	92	186.8	172.1	66.3	485.3	551.6	1.60	.625	.02719	36.78	54.26	431.04	.1268	.880
553	93	190	175.3	67.4	484.1	551.5	1.57	.637	.02724	36.72	54.24	429.86	.1288	.876
554	94	193.2	178.5	68.5	482.9	551.4	1.54	.647	.02727	36.67	54.22	428.68	.1308	.872

TABLE XLII — *Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pound per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
555	95	196	181.3	69.7	481.7	551.4	1.52	.658	.02732	36.61	54.20	427.50	.1328	.868
556	96	199	184.3	70.8	480.5	551.3	1.49	.668	.02735	36.55	54.17	426.33	.1348	.864
557	97	202.4	187.7	72.0	479.3	551.3	1.47	.680	.02739	36.50	54.15	425.15	.1369	.860
558	98	205.6	190.9	73.0	478.1	551.1	1.44	.691	.02743	36.44	54.12	424.03	.1390	.857
559	99	209	194.3	74.2	476.8	551.0	1.42	.701	.02747	36.39	54.09	422.71	.1410	.853
560	100	212.5	197.8	75.3	475.5	550.8	1.40	.714	.02753	36.33	54.07	421.43	.1432	.849
561	101	215	200.3	76.4	474.3	550.7	1.38	.724	.02756	36.27	54.04	420.26	.1452	.846
562	102	218.5	203.8	77.6	473.1	550.7	1.36	.735	.02761	36.22	54.01	419.09	.1472	.842
563	103	222	207.3	78.8	471.9	550.7	1.34	.746	.02765	36.16	53.98	417.92	.1492	.838
564	104	225.5	210.8	79.8	470.6	550.4	1.32	.758	.02770	36.10	53.95	416.65	.1512	.836
565	105	229	214.3	81.0	469.4	550.4	1.30	.769	.02775	36.04	53.92	415.48	.1532	.831
566	106	232.5	217.8	82.2	468.1	550.3	1.28	.781	.02779	35.99	53.89	414.26	.1552	.827
567	107	236	221.3	83.4	466.8	550.2	1.26	.794	.02783	35.93	53.86	412.94	.1572	.823
568	108	239	224.3	84.6	465.6	550.2	1.24	.806	.02787	35.87	53.83	411.77	.1592	.820
569	109	243	228.3	85.8	464.3	550.1	1.22	.820	.02791	35.82	53.80	410.50	.1612	.816
570	110	247	232.3	86.9	463	549.9	1.20	.833	.02796	35.76	53.76	409.24	.1632	.812
571	111	251	236.3	88.1	461.7	549.8	1.18	.847	.02801	35.70	53.72	407.98	.1653	.809
572	112	255	240.3	89.2	460.4	549.6	1.16	.862	.02806	35.64	53.69	406.71	.1673	.805
573	113	259	244.3	90.4	459.1	549.5	1.14	.873	.02810	35.59	53.65	405.45	.1693	.801
574	114	263	248.3	91.5	457.8	549.3	1.13	.885	.02815	35.53	53.61	404.19	.1714	.798
575	115	267	252.3	92.7	456.5	549.2	1.11	.900	.02819	35.47	53.57	402.93	.1734	.794
576	116	271	256.3	93.8	455.1	548.9	1.09	.917	.02824	35.41	53.53	401.62	.1753	.791
577	117	275.5	260.8	95.0	453.8	548.8	1.08	.926	.02828	35.35	53.49	400.31	.1773	.787
578	118	280	265.3	96.1	452.4	548.5	1.06	.943	.02833	35.29	53.45	398.95	.1793	.784
579	119	284	269.3	97.3	451	548.4	1.04	.957	.02839	35.23	53.40	397.60	.1813	.780
580	120	288	273.3	98.4	449.6	548.0	1.03	.970	.02843	35.17	53.36	396.24	.1832	.776
581	121	292	277.3	99.6	448.3	547.9	1.01	.985	.02848	35.11	53.31	394.99	.1852	.772

Table XLII — *Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
582	122	296	281.3	100.8	447	547.8	1.000	1.0	.02853	35.05	53.26	393.74	.1872	.769
583	123	299	284.3	101.9	445.6	547.5	.99	1.01	.02857	34.99	53.21	392.39	.1893	.765
584	124	303	288.3	103.0	444.3	547.3	.975	1.02	.02863	34.93	53.17	391.13	.1913	.761
585	125	307.5	292.8	104.2	443.0	547.2	.960	1.04	.02867	34.87	53.12	389.88	.1933	.758
586	126	312	297.3	105.4	441.7	547.1	.945	1.06	.02873	34.81	53.06	388.64	.1953	.754
587	127	316	301.3	106.6	440.3	546.9	.930	1.07	.02877	34.75	53.01	387.29	.1973	.750
588	128	320	305.3	107.8	439.0	546.8	.920	1.08	.02881	34.69	52.95	386.05	.1993	.746
589	129	325	310.3	109.0	437.5	546.5	.910	1.09	.02887	34.63	52.90	384.60	.2013	.743
590	130	330	315.3	110.2	436.2	546.4	.890	1.12	.02893	34.57	52.85	383.35	.2033	.739
591	131	335	320.3	111.3	434.8	546.1	.88	1.13	.02898	34.50	52.79	382.06	.2053	.736
592	132	340	325.3	112.4	433.5	545.9	.87	1.15	.02902	34.44	52.73	380.77	.2072	.732
593	133	345	330.3	113.6	432.1	545.7	.855	1.17	.02909	34.38	52.66	379.44	.2092	.728
594	134	350	335.3	114.8	430.8	545.6	.84	1.19	.02914	34.32	52.60	378.20	.2112	.725
595	135	355	340.3	116.0	429.4	545.4	.83	1.20	.02919	34.25	52.53	376.87	.2133	.721
596	136	360	345.3	117.1	428.0	545.1	.815	1.23	.02925	34.19	52.47	375.53	.2153	.718
597	137	365	350.3	118.2	426.6	544.8	.805	1.24	.02931	34.12	52.40	374.20	.2173	.714
598	138	370	355.3	119.4	425.3	544.7	.79	1.26	.02938	34.06	52.32	372.98	.2193	.711
599	139	375	360.3	120.6	423.9	544.5	.78	1.28	.02941	34.00	52.25	371.65	.2213	.707
600	140	380.5	365.8	121.8	422.5	544.3	.77	1.30	.02945	33.94	52.18	370.32	.2232	.703
601	141	386	371.3	123.0	421.0	544.0	.76	1.31	.02952	33.88	52.10	368.95	.2253	.700
602	142	391	376.3	124.2	419.6	543.8	.75	1.33	.02957	33.82	52.03	367.57	.2273	.697
603	143	396	381.3	125.4	418.1	543.5	.74	1.35	.02962	33.75	51.96	366.19	.2292	.693
604	144	402	387.3	126.6	416.6	543.2	.73	1.37	.02968	33.69	51.88	364.77	.2312	.690
605	145	407	392.3	127.9	415.2	543.1	.72	1.39	.02974	33.63	51.80	363.40	.2332	.686
606	146	412	397.3	129.0	413.7	542.7	.71	1.41	.02980	33.56	51.72	362.03	.2352	.683
607	147	418	403.3	130.3	412.3	542.6	.7	1.43	.02985	33.50	51.64	360.66	.2372	.679
608	148	424	409.3	131.5	410.8	542.3	.69	1.45	.02992	33.43	51.55	359.25	.2392	.675

TABLE XLII — *Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
609	149	429	414.3	132.8	409.3	542.1	.68	1.47	.02998	33.37	51.46	357.84	.2412	.672
610	150	435	420.3	134.0	407.8	541.8	.67	1.49	.03003	33.30	51.38	356.42	.2432	.668
611	151	440	425.3	135.2	406.3	541.5	.66	1.51	.03010	33.23	51.29	355.01	.2450	.665
612	152	448	433.3	136.3	404.9	541.2	.65	1.54	.03016	33.17	51.20	353.70	.2470	.661
613	153	452	437.3	137.6	403.4	541.0	.641	1.56	.03021	33.10	51.10	352.30	.2490	.658
614	154	457	442.3	138.8	401.9	540.7	.632	1.58	.03028	33.03	51.00	350.90	.2511	.654
615	155	463	448.3	140.0	400.3	540.3	.624	1.60	.03034	32.97	50.90	349.40	.2530	.651
616	156	469	454.3	141.2	398.8	540.0	.616	1.62	.03039	32.90	50.80	348.00	.2549	.648
617	157	475	460.3	142.4	397.3	539.7	.608	1.64	.03046	32.83	50.70	346.60	.2569	.644
618	158	481	466.3	143.6	395.7	539.3	.600	1.66	.03053	32.76	50.60	345.10	.2588	.640
619	159	486	471.3	144.9	394.0	538.9	.594	1.68	.03058	32.69	50.50	343.50	.2608	.637
620	160	492	477.3	146.2	392.5	538.7	.588	1.72	.03065	32.62	50.40	342.10	.2628	.633
621	161	498	483.3	147.4	391.0	538.4	.578	1.75	.03072	32.55	50.29	340.71	.2648	.630
622	162	504	489.3	148.6	389.4	538.0	.568	1.76	.03080	32.48	50.18	339.22	.2668	.626
623	163	510	495.3	149.9	387.7	537.6	.560	1.78	.03086	32.40	50.06	377.64	.2688	.623
624	164	518	503.3	151.1	386.1	537.2	.550	1.82	.03094	32.33	49.95	336.15	.2707	.619
625	165	523	508.3	152.4	384.4	536.8	.542	1.85	.03100	32.26	49.83	334.57	.2726	.616
626	166	529	514.3	153.6	382.8	536.4	.532	1.88	.03109	32.18	49.72	333.08	.2746	.612
627	167	536	521.3	154.9	381.1	536.0	.524	1.91	.03115	32.11	49.60	331.50	.2764	.608
628	168	542	527.3	156.1	379.5	535.6	.516	1.94	.03122	32.04	49.48	330.02	.2784	.605
629	169	549	534.3	157.4	377.8	535.2	.508	1.97	.03129	31.97	49.36	328.44	.2802	.601
630	170	556	541.3	158.6	376.1	534.7	.502	1.99	.03135	31.90	49.24	326.86	.2820	.597
631	171	563	548.3	159.7	374.4	534.1	.494	2.02	.03143	31.82	49.12	325.28	.2840	.594
632	172	570	555.3	160.8	372.7	533.5	.488	2.05	.03149	31.75	49.00	323.70	.2860	.590
633	173	575	560.3	162.0	371.0	533.0	.482	2.07	.03157	31.67	48.88	322.12	.2880	.586
634	174	584	569.3	163.2	369.3	532.5	.476	2.10	.03165	31.60	48.75	320.55	.2898	.583
635	175	590	575.3	164.5	367.6	532.1	.470	2.13	.03171	31.53	48.62	318.98	.2918	.579

TABLE XLII — *Continued*

PROPERTIES OF SATURATED AMMONIA VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
636	176	598	583.3	165.7	366.0	531.7	.464	2.16	.03179	31.45	48.50	317.50	.2936	.575
637	177	605	590.3	166.9	364.1	531.0	.458	2.18	.03187	31.38	48.36	315.74	.2956	.572
638	178	612	597.3	168.1	362.4	530.5	.454	2.20	.03195	31.30	48.23	314.17	.2976	.568
639	179	620	605.3	169.4	360.6	530.0	.450	2.22	.03203	31.22	48.10	312.50	.2994	.564
640	180	626	611.3	170.6	358.8	529.4	.446	2.24	.03210	31.15	47.96	310.84	.3010	.560
641	181	634	619.3	171.8	356.9	528.7	.440	2.27	.03218	31.07	47.82	309.08	.3032	.557
642	182	640	625.3	173.0	355.0	528.0	.434	2.30	.03226	31.00	47.68	307.32	.3050	.553
643	183	648	633.3	174.3	352.9	527.2	.428	2.33	.03234	30.92	47.54	305.36	.3070	.549
644	184	656	641.3	175.5	351.0	526.5	.420	2.38	.03241	30.85	47.40	303.65	.3089	.545
645	185	664	649.3	176.8	349.0	525.8	.416	2.40	.03250	30.77	47.26	301.74	.3108	.542
646	186	670	655.3	178.0	347.0	525.0	.408	2.45	.03259	30.67	47.12	299.88	.3128	.538
647	187	679	664.3	179.3	345.0	524.3	.402	2.49	.03266	30.62	46.98	298.02	.3148	.536
648	188	686	671.3	180.5	343.0	523.5	.396	2.53	.03274	30.54	46.84	296.16	.3168	.530
649	189	694	679.3	181.8	341.0	522.8	.392	2.55	.03283	30.46	46.70	294.30	.3188	.526
650	190	702	687.3	183.0	339.0	522.0	.386	2.57	.03292	30.38	46.55	292.45	.3206	.522
651	191	710	695.3	184.3	336.9	521.2	.380	2.63	.03300	30.30	46.40	290.50	.3224	.518
652	192	719	704.3	185.5	334.8	520.3	.374	2.67	.03310	30.21	46.26	288.54	.3244	.514
653	193	728	713.3	186.8	332.8	519.6	.370	2.70	.03319	30.13	46.11	286.69	.3264	.510
654	194	736	721.3	188.0	330.7	518.7	.364	2.75	.03329	30.04	45.96	284.74	.3284	.506
655	195	744	729.3	189.2	328.6	517.8	.360	2.78	.03339	29.96	45.82	282.58	.3304	.502
656	196	752	737.3	190.4	326.5	516.9	.354	2.82	.03349	29.87	45.67	280.83	.3324	.498
657	197	762	747.3	191.7	324.4	516.1	.350	2.86	.03360	29.78	45.52	278.88	.3344	.494
658	198	770	755.3	192.9	322.3	515.2	.344	2.90	.03370	29.68	45.37	276.93	.3364	.490
659	199	780	765.3	194.2	320.1	514.3	.340	2.94	.03380	29.59	45.21	274.89	.3384	.486
660	200	788	773.3	195.5	318.0	513.5	.336	2.98	.03390	29.50	45.05	272.95	.3403	.482

Table XLIII

PROPERTIES OF SATURATED CARBON DIOXIDE VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Liquid Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
440	−20	219.5	204.8	−24	122.6	98.6	.01576	63.45	.3782	2.644	14.80	107.8	.05129	.2786
441	−19	223	208.3	−23.6	122.2	98.6	.01578	63.37	.3708	2.697	14.79	107.41	.05068	.2771
442	−18	227.9	213.2	−23.2	121.8	98.6	.015804	63.27	.3636	2.747	14.78	107.02	.04952	.2755
443	−17	232.6	217.9	−22.8	121.4	98.6	.015830	63.17	.3564	2.808	14.76	106.64	.04882	.2740
444	−16	237.8	221.1	−22.4	121.0	98.6	.015856	63.07	.3494	2.860	14.74	106.26	.04769	.2725
445	−15	242.6	227.9	−22.0	120.6	98.6	.01588	62.97	.3425	2.919	14.73	105.87	.04697	.2710
446	−14	248	233.3	−21.6	120.2	98.6	.015908	62.86	.3360	2.976	14.72	105.48	.04583	.2695
447	−13	253.8	239.1	−21.2	119.8	98.6	.015936	62.75	.3300	3.030	14.70	105.1	.04506	.2680
448	−12	259	244.3	−20.8	119.4	98.6	.015961	62.66	.3240	3.086	14.68	104.72	.04391	.2665
449	−11	264.6	249.9	−20.3	118.95	98.6	.015988	62.54	.3180	3.143	14.66	104.29	.04317	.2649
450	−10	270	255.3	−19.9	118.5	98.6	.016016	62.43	.3121	3.204	14.64	103.86	.04196	.2633
451	− 9	274	259.3	−19.5	118.2	98.6	.016044	62.30	.3062	3.258	14.62	103.58	.04122	.2621
452	− 8	277.7	263.0	−19.0	117.65	98.6	.016072	62.22	.3016	3.311	14.61	103.04	.04002	.2603
453	− 7	281.8	267.1	−18.6	117.20	98.6	.01610	62.11	.2970	3.367	14.60	102.60	.03925	.2587
454	− 6	286	271.3	−18.2	116.85	98.65	.016128	62.00	.2922	3.422	14.59	102.26	.03848	.2573
455	− 5	290.2	275.5	−17.8	116.45	98.65	.016156	61.90	.2875	3.478	14.58	101.88	.03725	.2559
456	− 4	294.7	280	−17.3	116.05	98.7	.016184	61.78	.2830	3.534	14.55	101.5	.03647	.2545
457	− 3	299.2	284.5	−16.9	115.6	98.7	.016212	61.68	.2785	3.590	14.53	101.07	.03518	.2530
458	− 2	303.8	289.1	−16.4	115.20	98.75	.01624	61.58	.2743	3.642	14.51	100.69	.03441	.2514
459	− 1	308.7	294	−16.0	114.75	98.75	.016269	61.46	.2702	3.700	14.50	100.25	.03360	.2500
460	0	313.5	298.8	−15.5	114.3	98.8	.016298	61.35	.2661	3.756	14.49	99.81	.03278	.2484
461	1	318.7	304.0	−15.0	113.85	98.80	.016324	61.25	.2620	3.817	14.48	99.37	.03151	.2470
462	2	323.8	309.1	−14.6	113.4	98.8	.016353	61.15	.2580	3.876	14.47	98.93	.03068	.2454
463	3	329	314.3	−14.1	113.00	98.85	.016382	61.05	.2540	3.937	14.46	98.54	.02986	.2441
464	4	334	319.3	−13.7	112.55	98.85	.016410	60.94	.2500	4.000	14.45	98.1	.02853	.2426
465	5	339.5	324.8	−13.2	112.10	98.85	.016440	60.83	.2460	4.065	14.44	97.66	.0277	.2411

TABLE XLIII—*Continued*

PROPERTIES OF SATURATED CARBON DIOXIDE VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
466	6	345	330.3	−12.8	111.65	98.85	.016472	60.71	.2424	4.125	14.43	97.22	.02683	.2396
467	7	350.6	335.9	−12.3	111.15	98.85	.016504	60.58	.2387	4.190	14.42	96.73	.02597	.2380
468	8	356	341.3	−11.8	110.7	98.9	.016532	60.48	.2351	4.253	14.42	96.28	.02463	.2365
469	9	362	347.3	−11.3	110.20	98.90	.016563	60.37	.2316	4.317	14.42	95.78	.02375	.2350
470	10	368	353.3	−10.9	109.8	98.9	.016594	60.26	.2282	4.382	14.42	95.38	.02288	.2336
471	11	373.8	359.1	−10.4	109.3	98.9	.016628	60.12	.2250	4.44	14.42	94.88	.02197	.2321
472	12	380	365.3	−10.05	108.90	98.85	.016664	60.00	.2217	4.514	14.42	94.48	.02061	.2307
473	13	386	371.3	− 9.5	108.35	98.85	.016700	59.88	.2184	4.581	14.42	93.93	.01970	.2291
474	14	392.5	377.8	− 9.05	107.9	98.85	.016736	59.75	.2152	4.649	14.42	93.48	.0189	.2276
475	15	399	384.3	− 8.6	107.4	98.8	.016772	59.63	.2121	4.717	14.42	92.98	.01786	.2261
476	16	405.5	390.8	− 8.15	106.95	98.8	.016808	59.49	.2090	4.785	14.42	92.53	.01695	.2247
477	17	412	397.3	− 7.65	106.40	98.75	.016844	59.36	.2060	4.854	14.42	91.98	.01553	.2231
478	18	418.7	404.0	− 7.15	105.90	98.75	.016884	59.23	.2029	4.933	14.41	91.49	.01458	.2215
479	19	425.5	410.8	− 6.7	105.4	98.7	.016924	59.08	.1997	5.010	14.39	91.01	.01363	.2200
480	20	432	417.3	− 6.2	104.9	98.7	.016964	58.92	.1965	5.092	14.37	90.53	.01268	.2185
481	21	439	424.3	− 5.65	104.35	98.7	.017004	58.80	.1933	5.173	14.34	90.01	.01171	.2170
482	22	446	431.3	− 5.1	103.75	98.65	.017044	58.66	.1905	5.249	14.32	89.43	.01074	.2152
483	23	453	438.3	− 4.6	103.15	98.55	.017084	58.52	.1876	5.330	14.30	88.85	.009248	.2136
484	24	460	445.3	− 4.1	102.6	98.5	.017128	58.37	.1848	5.411	14.28	88.32	.00826	.2120
485	25	467	452.3	− 3.6	102	98.4	.017172	58.23	.1820	5.495	14.26	87.74	.00726	.2104
486	26	474.5	459.8	− 3.05	101.35	98.3	.017216	58.09	.1793	5.577	14.24	87.11	.006247	.2085
487	27	482	467.3	− 2.55	100.75	98.2	.017260	57.94	.1765	5.665	14.20	86.55	.005226	.2069
488	28	489	474.3	− 2.05	100.15	98.1	.017314	57.75	.1738	5.754	14.16	85.99	.004202	.2052
489	29	496.5	481.8	− 1.55	99.55	98	.017358	57.61	.1711	5.844	14.12	85.43	.003164	.2036
490	30	503	488.3	− 1.0	98.95	97.95	.017404	57.45	.1685	5.935	14.08	84.87	.002119	.2019
491	31	510.5	495.8	− .5	98.35	97.85	.017450	57.30	.1658	6.031	14.04	84.29	.001065	.2003

TABLE XLIII—*Continued*

PROPERTIES OF SATURATED CARBON DIOXIDE VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
492	32	518.2	503.5	.0	97.75	97.75	.017500	57.11	.1633	6.123	13.99	83.76	.0	.1987
493	33	526	511.3	.5	97.15	97.65	.017555	56.96	.1607	6.222	13.94	83.21	.001073	.1971
494	34	533.7	519.0	1.0	96.45	97.45	.017612	56.78	.1583	6.317	13.90	82.55	.002151	.1952
495	35	541	527.3	1.6	95.75	97.35	.017668	56.57	.1559	6.414	13.85	81.90	.003234	.1934
496	36	549	534.3	2.2	95.00	97.20	.017724	56.41	.1534	6.523	13.80	81.20	.004181	.1915
497	37	557	542.3	2.75	94.30	97.05	.017784	56.22	.1510	6.622	13.74	80.56	.005419	.1897
498	38	565	550.3	3.3	93.6	96.9	.017844	56.03	.1486	6.729	13.67	79.93	.006523	.1880
499	39	572.7	558.0	3.85	92.85	96.7	.017908	55.84	.1462	6.840	13.60	79.25	.007644	.1861
500	40	580.2	565.5	4.4	92.1	96.5	.017974	55.63	.1441	6.940	13.54	78.56	.008753	.1842
501	41	588	573.3	5.0	91.3	96.3	.018040	55.43	.1417	7.067	13.46	77.84	.009869	.1822
502	42	596	581.3	5.6	90.5	96.1	.018112	55.21	.1392	7.184	13.36	77.14	.0110	.1803
503	43	603.5	588.8	6.2	89.65	95.85	.018184	54.99	.1370	7.299	13.27	76.38	.01215	.1782
504	44	611.2	596.5	6.8	88.8	95.6	.018256	54.78	.1347	7.424	13.17	75.63	.01329	.1762
505	45	619	604.3	7.4	88.0	95.4	.018334	54.60	.1324	7.553	13.07	74.93	.01444	.1742
506	46	627.5	612.8	8.0	87.1	95.1	.018416	54.27	.1301	7.692	12.97	74.14	.01563	.1721
507	47	635.5	620.8	8.6	86.1	94.7	.018496	54.05	.1278	7.825	12.86	73.24	.01681	.1698
508	48	644	629.3	9.2	85.2	94.4	.018576	53.84	.1255	7.968	12.75	72.45	.01798	.1677
509	49	652.7	638.0	9.8	84.25	94.05	.018666	53.57	.1233	8.110	12.64	71.61	.01919	.1655
510	50	661	646.3	10.4	83.3	93.7	.018760	53.30	.1211	8.258	12.52	70.78	.02037	.1633
511	51	669	654.3	11.0	82.40	93.40	.018850	53.10	.1190	8.403	12.40	70.00	.02160	.1613
512	52	677	662.3	11.6	81.45	93.05	.018940	52.80	.1168	8.562	12.26	69.19	.02283	.1591
513	53	685	670.3	12.25	80.50	92.75	.019038	52.52	.1147	8.718	12.12	68.38	.02406	.1569
514	54	693.5	678.8	12.9	79.5	92.4	.019136	52.26	.1126	8.881	11.98	67.52	.02543	.1547
515	55	701.5	686.8	13.55	78.50	92.05	.019236	51.98	.1105	9.050	11.85	66.65	.02658	.1524
516	56	710	695.3	14.2	77.45	91.65	.019336	51.71	.1085	9.217	11.72	65.73	.02844	.1500
517	57	719.5	704.8	14.85	76.30	91.15	.019448	51.41	.1065	9.390	11.59	64.71	.02973	.1476

TABLE XLIII—*Continued*

PROPERTIES OF SATURATED CARBON DIOXIDE VAPOR

Abs. Temp. ° F.	Scale, Temp. ° F.	Pressure, Pounds per Sq.in. Absolute.	Pressure, Pounds per Sq.in. Gage.	Heat of Liquid Above 32° F.	Latent Heat.	Total Heat Above 32° F.	Sp. Vol. of Liquid, Cu.ft. per Pound.	Density of Liquid, Pounds per Cu.ft.	Sp. Vol. of Vapor, Cu.ft. per Pound.	Density of Vapor, Pounds per Cu.ft.	External Latent Heat.	Internal Latent Heat.	Entropy of Liquid.	Entropy of Vapor.
518	58	729	714.3	15.5	75.15	90.65	.019560	51.12	.1045	9.570	11.46	63.69	.03105	.1451
519	59	738.5	723.8	16.15	74.00	90.15	.019672	50.83	.1026	9.747	11.33	62.67	.03237	.1425
520	60	748	733.3	16.8	72.85	89.65	.019792	50.52	.1006	9.940	11.19	61.66	.03371	.1400
521	61	758	743.3	17.55	71.60	89.15	.019920	50.20	.0986	10.142	11.04	60.56	.03507	.1374
522	62	768	753.3	18.3	70.3	88.6	.020044	49.87	.0966	10.352	10.89	59.41	.03643	.1348
523	63	778	763.3	19.1	69	88.1	.020168	49.67	.0946	10.571	10.74	58.26	.03783	.1319
524	64	788	773.3	19.9	67.65	87.55	.020298	49.28	.0926	10.799	10.56	57.09	.03926	.1291
525	65	798.5	783.8	20.7	66.3	87.00	.020440	48.86	.0906	11.038	10.37	55.93	.04067	.1263
526	66	809.5	794.8	21.5	64.9	86.4	.020592	48.57	.0886	11.287	10.18	54.72	.04218	.1234
527	67	820.5	805.8	22.3	63.5	85.8	.020744	48.18	.0866	11.547	9.98	53.52	.04363	.1205
528	68	830.5	815.8	23.1	62.1	85.2	.020896	47.85	.0846	11.820	9.78	52.32	.04517	.1176
529	69	841	826.3	23.9	60.6	84.5	.021050	47.45	.0826	12.107	9.58	51.02	.04683	.1145
530	70	851.5	836.8	24.75	59.05	83.8	.021240	47.08	.0806	12.407	9.36	49.69	.04837	.1114
531	71	860.5	845.8	25.6	57.45	83.05	.021420	46.68	.0786	12.722	9.12	48.33	.0500	.1082
532	72	871	856.3	26.5	55.8	82.3	.021600	46.30	.0766	13.055	8.87	46.93	.05169	.1048
533	73	882	867.3	27.4	54.2	81.6	.021800	45.87	.0746	13.405	8.62	45.58	.05343	.1017
534	74	892	877.3	28.4	52.5	80.9	.022000	45.45	.0727	13.757	8.37	44.13	.05454	.09831
535	75	902	887.3	29.4	50.8	80.2	.022232	44.98	.0708	14.124	8.11	42.69	.05718	.09495
536	76	912.5	897.8	30.4	49.05	79.45	.022472	44.50	.0690	14.493	7.86	41.19	.05901	.09151
537	77	923	908.3	31.4	47.25	78.65	.022720	44.00	.0672	14.881	7.60	39.65	.06098	.08798
538	78	934	919.3	32.5	45.35	77.85	.023000	43.48	.0653	15.314	7.33	38.12	.06298	.08429
539	79	944.5	929.8	33.6	43.45	77.05	.023280	42.94	.0634	15.773	7.03	36.44	.06506	.08061
540	80	955	940.3	34.7	41.6	76.3	.023600	42.37	.0616	16.234	6.72	34.88	.06714	.07704

TABLE

SOLUTIONS OF

RELATION BETWEEN PRESSURE, TEMPERATURE,

Upper figures are Starr values,

Per Cent NH_3 by Weight.	Degrees Baumé.	Specific Gravity.	Pounds per Square Inch Gage											
			0	5	10	15	20	25	30	35	40	45	50	55
1	...	...	206.3	223.6	234.9	247.4	256.2	263.8	270.4	277.1	282.8	288.1	292.9	297.5
			204	219	232	242	251	260	267	274	280	286	291.5	297
1.84	11	.993	201.4	219.3	231.5	243.3	251.7	259.4	266.4	272.7	278.4	283.7	288.5	293.1
			198.5	214	226	236.5	245.5	254	261.5	269.5	274.5	281	286.5	292
2	...	...	201.1	218.5	230.8	242.1	250.9	258.6	265.5	271.9	277.6	282.8	287.7	292.2
			194	212.5	225	235.5	244.5	253	260.5	267.5	273.5	280	285.5	291
3	...	...	195.8	213.2	225.5	236.6	245.6	253.3	260.2	266.8	272.3	277.5	282.4	286.9
			191	206	219	229	238	246.5	254	261.5	267	274.5	280	285
3.80	12	.986	191.5	208.8	221	232.3	241	248.7	255.7	262	267.7	272.9	277.8	282.4
			186.5	200.5	214	224.5	233	241.5	249.5	256	262.5	269.5	274.5	280.5
4	...	...	190.5	207.7	220	231.2	240	247.6	254.7	260.9	266.7	271.8	276.1	281.4
			185	200	213	223	232	240.5	248	255	261	268	273.5	279.5
5	...	...	185.2	202.4	214.6	225.8	234.6	242.2	249.3	255.6	261.4	266.5	271.4	276.1
			180	195	207.5	217.5	226.5	235	242	249	255	262.5	268	273.5
5.30	13	.979	183.5	200.7	212.8	224.1	232.8	240.5	247.5	253.8	259.6	264.8	270.2	274.1
			178	192.5	206	216	225	234	240.5	252.5	254	261	266	272
6	...	...	180	197.1	209.2	220.5	229.2	237	243.9	250.2	256.1	261.2	266.7	271.2
			175	189.5	202	212.5	221	229.5	237	248.5	249.5	257	262.5	268
6.80	14	.972	175.8	193	205	216.2	224.9	232.6	239.6	246.0	251.8	257	262.1	266.7
			171	185.5	198.5	208.5	217	225	232.5	239.5	245.5	252.5	258	263.5
7	...	...	170	192.1	204	215.3	223.9	231.7	238.6	245.1	250.8	256.1	261.1	265.8
			170	184.5	197.5	207.5	216	224	231.5	238.5	244.5	251.5	257	262.5
8	...	...	168.8	187.2	199.1	210.3	218.9	226.9	233.7	240.1	245.9	251.2	266.2	260.8
			165.5	180	193	203	211.5	219.5	227	233.5	239.5	246	252	257.5
8.22	15	.966	165.4	185.8	197.8	209	217.7	225.4	232.4	238.6	244.2	249.3	254.1	258.7
			164.5	179	191.5	202	210.5	218.5	226	232.5	239	245	250.5	256.5
9	...	...	160.8	182.5	194.5	205	214.3	222	229	235.2	240.8	245.9	250.7	255.3
			161	175.5	188.5	198.5	207	215	222.5	229	235	241.5	247	252.5
10	16	.960	156	177.7	189.6	200.6	209.2	216.9	223.9	230.1	235.5	240.6	245.4	250
			156.5	171.5	184.5	194.0	203	211	218	225	230.5	237	242.5	247.5
11	...	...	156.4	173.2	185.1	196.1	204.7	212.4	219.4	225.6	231	236.1	240.9	244.5
			152.5	167.5	179.5	190	198.5	206.5	213.5	220	226	232.5	237.5	242.5
12	...	...	151.9	168.9	180.6	191.9	199.6	208.3	214.8	221	226.4	231.5	236.4	240.0
			149	163	175.5	185.5	194.5	202.5	209.5	216	222	228	233	238
12.17	17	.953	151	168	179.9	191.0	199.6	207.3	213.6	219.6	225.0	230.3	234.4	239.0
			147.5	162	174.5	184.5	192.5	201.5	208.5	215	221	227	232.5	237
13	...	...	147.5	164.4	176.4	187.4	196.1	203.7	210.1	216.1	221.4	226.8	230.8	235.5
			144.5	159	171	181.5	190	198	205	211.5	217.5	223.5	228.5	233.5
13.88	18	.946	143.7	160.5	172.3	183.4	192	199.7	206	212.1	217.6	222.7	227.2	231.8
			141	155	167.5	178	186.5	194.5	201.5	207.5	214	219.5	224.5	230.0
14	...	...	143.2	160	171.8	182.9	191.5	199.2	205.5	211.6	217.1	222.2	226.7	231.3
			140.5	154.5	167	177.5	186	193.5	201	207	213.5	219	224	228.5
15	...	...	139	155.8	167.6	178.7	187.3	195.0	201.3	207.4	212.9	218.0	222.5	227.1
			137	151	163	173.5	182	190	197	203	209.5	215	220.0	225
16	...	...	134.8	151.6	163.4	174.5	183.1	190.8	197.1	203.2	208.7	213.8	218.3	222.9
			132.5	147	159	169.5	178	186	192.5	199	205	211	215.5	220.5
16.22	19	.94	133.8	150.6	162.3	173.3	181.4	189.5	196	201.8	207.1	212.3	217.1	221.7
			131.5	146	157.5	168.5	177	185	192	198	204.5	210	215.0	220.0
17	...	...	130.6	147.4	159.1	170.1	178.2	186.3	192.8	198.6	203.9	209.1	213.9	218.5
			129	143	155	165.5	174	182	188	195	201	207	211.5	216.5
18.03	20	.935	126.2	142.9	154.6	165.6	174.2	181.9	188.9	195.1	200.7	205.7	209.5	214.1
			125	139	151	161.5	170	177.5	184.5	191	197	202.5	207.5	212.5
19	...	...	122.3	138.9	150.7	161.6	170.3	177.9	185.0	191.1	196.8	201.7	205.6	210.1
			121.5	135.5	147.5	157.5	166.5	173.5	180.5	187	193	198.5	203.0	208.5

XLIV
AMMONIA IN WATER
AND PER CENT NH_3 IN SOLUTION

lower figures are new.

Above One Standard Atmosphere														
60	65	70	75	80	85	90	95	100	105	110	115	Specific Gravity.	Degrees Baumé.	Per Cent NH_3 by Weight.
301.9	306.3	310.4	314.4	318.2	321.8	325.2	328.5	331.7	334.8	337.8	340.7	...	...	1
301.5	306	310	315	318.5	322	325.5	329	307.5	335.5	339	341.5			
297.5	301.8	306	310	313.8	317.4	320.8	324.1	327.3	330.4	333.4	336.3	.993	11	1.84
296.5	301	305.5	310	313.5	317.5	321	324.5	330.5	331	334	337			
296.7	300.9	305.2	309.2	312.9	316.6	320	323.2	326.5	329.6	332.6	335.4	...	...	2
295.5	300	304.5	309	312.5	316	320	323.5	327	330	333	336			
291.4	295.6	300	303.9	307.6	311.3	314.7	317.9	321.2	324.3	327.3	330.1	...	...	3
289.5	294.5	299	303	307	311	314.5	317.5	320.5	324	327.5	330			
286.8	291.1	295.3	299.3	303.1	306.7	310.1	313.4	316.6	319.7	322.7	325.6	.986	12	3.80
284.5	290	294	298.5	302	306.5	310	313	316	320	323	325.5			
285.7	290.1	294.2	298.3	302.1	305.6	309.1	312.4	315.5	318.7	321.6	324.5	...	...	4
284	289	293	297.5	301	305.5	309	312	315	318.5	326.5	324.5			
280.4	284.8	288.9	293	296.3	300.3	303.8	307.1	310.2	313.4	316.3	319.2	...	...	5
278.5	283	287.5	292	295.5	299.5	303	306	310	313	316.5	319			
279.2	283.5	287.1	291.7	295.5	299.1	302.5	305.8	309	312.1	315.1	318	.979	13	5.30
276.5	281.5	285.5	290	294	298	301	304.5	307.5	311	315	317.5			
275.6	280	284.1	288.2	291.9	295.5	299	302.2	305.5	308.5	311.6	314.4	...	...	6
273	277.5	281.5	286	290	294	302	300.5	304	307	310.5	313.5			
271.1	275.4	279.6	283.6	287.4	291	294.4	297.1	300.9	304	307	309,0	.972	14	6.80
269	278.5	277.5	281.5	285.5	289.5	303	296	300.5	303	306.5	309			
270.1	274.5	278.6	282.7	286.4	290.1	293.5	296.7	300	303	306.1	308.9	...	...	7
267.5	277.5	276.5	281	284.5	288.5	302	295	299.5	302	305	308			
265.2	269.6	273.7	281.7	281.5	285.2	288.6	291.7	295.1	298.1	301.2	303.9	...	...	8
262	267	271.5	275.5	279.5	283.5	287	290	293	296.5	300	303			
263.1	267.4	271.6	275.6	279.4	283	286.4	289.7	292.4	296	299	301.9	.966	15	8.22
261	266	270	274.5	278	282.5	286	289	292	295.5	296.5	301.5			
259.7	264	268.2	272.2	276	279.6	283	286.3	289.6	292.6	295.6	308.5	...	...	9
257	262	266.5	270.5	274.5	278	282	285	282	291.5	294.5	297.5			
254.4	258.7	262.9	266.9	270.7	274.3	277.7	281	284.2	287.3	230.3	293.2	.960	16	10
252.5	257.5	261.5	265.5	269.5	274	277	280	277	287	290	293			
249.9	254.2	258.4	262.4	266.2	268.8	273.2	276.5	279.7	282.8	285.8	288.7	...	...	11
247.5	252.5	256.5	260.5	264.5	268.5	272.5	275	272	282	285	288			
245.4	249.8	253.9	257.9	261.7	264.3	268.7	272	275.2	278.3	281.3	289.2	...	...	12
242.5	247.5	251.5	256	259.5	264	267.5	270	267	277	280	283			
243.4	247.7	251.9	255.4	259.7	263.3	266.7	270	273.2	276.3	279.3	282.2	.953	17	12.17
242	246.5	251	255	253.5	263	266.5	269	266.5	276	279	282			
239.9	244.2	248.4	251.8	256.2	259.8	263.1	266.5	269.6	272.8	275.7	278.6	...	...	13
238	243	247	251	255	258	263	266	262.5	272.5	275.5	278.5			
236.2	240.5	244	248.7	252.5	256.1	259.8	262.8	266	269.1	272.1	275	.946	18	13.88
234.5	239	243.5	247	250.5	255	259.0	261.5	258	268.5	271.5	274.5			
235.7	240	243.5	248.2	252	255.6	259	262.3	265.5	268.6	271.6	274.5	...	...	14
234	238.5	242.5	246.5	250	254.5	258.5	261	257.5	268	271	274			
231.5	235.8	239.4	244	247.8	251.4	254.8	258.1	261.3	264.4	267.4	270.3	...	...	15
229.5	234	238.5	242.5	246	250	254	256.5	260	263.5	266.5	270			
227.3	231.6	235.1	239.8	243.6	247.2	250.6	253.7	257.1	260.2	263.2	266.1	...	...	16
225	230	234	237.5	241.5	246	249.5	252	255.5	259	262	265			
226.1	230.4	234.6	238.6	242.4	246	249.4	252.7	255.9	259	262	264.9	.94	19	16.22
224.5	229	233.5	237	241	245	248.5	251.5	254.5	258	261	264			
222.9	227.2	231.4	235.4	239.2	242.8	246.2	249.5	252.7	255.8	258.8	261.7	...	...	17
221	225.5	230	233	237.5	241.5	245	248	251	254.5	257.5	260.5			
218.5	222.8	227	231	234.8	238.4	241.8	245.1	248.3	251.4	254.4	257.3	.935	20	18.03
217	221.5	225.5	229.5	233	237.5	241	243.5	247	250	253	256.5			
214.6	218.8	223.1	227	230.9	234.4	237.9	241.1	244.4	247.4	250.5	253.4	...	...	19
213	217.5	221.5	225	229	233	237	239.5	243	246	249	252			

TABLE

SOLUTIONS OF

RELATION BETWEEN PRESSURE, TEMPERATURE,

Per Cent NH_3 by Weight.	Degrees Baumé.	Specific Gravity.	Pounds per Square Inch Gage											
			0	5	10	15	20	25	30	35	40	45	50	55
19.87	21	.928	119.4	135.9	147.6	158.6	167.2	174.4	181.5	187.2	192.5	197.5	202.3	206.9
			118	132	144	154	163	170.5	177	184	189.5	195.5	200.5	205
20	...	...	118.9	135.5	147.1	158.2	166.7	174.4	181.1	186.7	192.1	197	201.9	206.4
			117.5	131.5	143.5	153.5	162.5	170	176.5	183.5	189	195	200	204.5
21	...	...	115.2	131.8	143.4	154.5	163.0	170.7	177.4	183.0	188.4	193.3	198.2	202.7
			114	128	140	150	158.5	166	173	179.5	185	191	195.5	200
21.75	22	.921	112.9	129.4	141	151.9	160.5	168.2	174.6	180.1	185.3	190.3	195.1	199.7
			111.5	125.5	137.5	147	155.5	163.5	170	176.5	182.5	188	193.0	197.5
22	...	...	112	128.5	140.1	151.0	159.6	167.3	173.7	179.2	184.4	189.4	194.2	198.8
			110.5	124	136.5	146	154.5	162.5	169	175.5	181.5	187	191.5	196
23.03	23	.915	108	124.5	136.1	147	155.6	163.3	170.0	175.4	180.2	185.2	190.0	194.8
			107	120.5	132.5	142.5	150.5	158.5	165	171.5	177.5	183	187.5	192.5
24	...	...	114.8	121.3	132.9	143.8	152.4	160.1	166.8	172.2	177.0	182	186.8	191.4
			103.5	117	129	138	147	154.5	161.5	168	174	179	184	188.5
24.99	24	.909	101.5	117.8	129.3	140.1	148.6	156.3	163	168.4	173.6	178.6	183.2	187.8
			99	113.5	125.5	135	143.5	151	158	164.5	170	175.5	180	185
26	...	...	98.3	114.6	126.2	136.9	145.5	153.1	159.8	165.3	170.4	175.5	179.9	184.7
			95.5	110.0	122.0	131.5	140	147	154	160.5	166.5	171.5	176.5	181
27	...	...	95.1	111.4	123.1	133.7	142.3	150.0	156.6	162.1	167.2	172.4	176.7	181.5
			92.5	106.5	118.5	128	136.5	143.5	150.5	157	162.5	168	172	177.5
27.66	25	.904	93.0	109.4	121.0	131.7	140.1	147.9	154.5	159.9	165.1	170.3	174.4	178.9
			90.0	104.0	116.5	126	134	141.5	148.5	154.5	160.5	165.5	171	175
28	...	...	92.0	108.3	120.0	130.6	139.1	146.8	153.4	158.9	164.0	169.3	173.3	177.9
			89.0	103	115	124.5	132.5	140	147	153.5	159	163	169.5	173.5
29	...	...	88.9	105.2	117.0	127.5	136	143.8	150.3	155.8	161	166.2	170.2	174.8
			86.0	99.5	111.5	121	129	136.5	143	149.5	155	160.5	165	170
29.60	26	.898	87	103.3	114.7	125.4	133.9	141.6	148.2	153.8	159	164.3	168.1	172.7
			83.5	97.5	109.5	119	127	134.5	141	147	152.5	158	163.5	167.5
30	...	...	85.8	102.1	113.5	124.2	132.7	140.4	147	152.6	157.8	163.1	166.9	171.6
			82.5	96.5	108	117.5	125.5	133	139.5	146	152	157	162	166
31.05	27	.891	82.6	98.8	110.2	120.9	129.4	137.1	143.5	149.2	154.5	159.8	163.6	168.3
			79.0	93.0	104.5	114	122	129.5	136	142	148	153	158.5	162.5
32	...	...	80.1	96.2	107.6	118.3	126.8	134.5	140.9	146.6	151.9	157.2	161.0	165.7
			76.0	89.5	101	110.5	118.5	126	132.5	138.5	144.5	149.5	154.5	159
33	...	...	77.4	93.5	104.9	115.6	124.1	131.8	138.7	143.9	149.2	154.5	158.3	163.0
			73.0	86.5	98	107	115.0	122.0	129	135	140.5	146	151.5	155.5
33.25	28	.886	76.5	92.6	103.9	114.6	123.1	130.8	137.8	143	148.3	153.6	157.4	162.1
			72.0	85.5	97	106.5	114.5	121.5	128	134	140	145	150.0	154.5
34	...	...	74.6	90.7	102	112.7	121.2	128.9	135.9	141.1	146.4	151.7	155.5	160.2
			69.5	83.0	94.5	104.0	111.5	119	125.5	131.5	137.5	142.5	147.5	152
35	...	...	72	88.1	99.4	110.1	118.6	126.3	133.3	138.5	143.8	149.1	152.9	157.8
			67.5	80.0	91.5	100.5	108.5	115.5	122	128	134.0	139	144	148.5
35.60	29	.881	70.4	86.5	97.8	108.5	117	124.7	131.7	137.9	142.2	147.5	151.3	156.0
			64.5	78.0	89	98.5	106	113.5	120	126	132	136.5	142	146
36	...	...	60.5	85.6	96.9	107.5	116.1	123.8	130.8	137.0	141.7	147.2	151.0	155.7
			63.5	77	88	97	105	112.5	118.5	124.5	130	135	140	145
37	...	...	67.2	83.3	94.6	105.2	113.8	121.5	128.5	134.7	140.7	146.8	150.2	154.9
			60.5	73.3	85.0	94	101.5	108.5	115.0	121.5	127	132	137	141
38	...	...	65.0	81.0	92.3	104.9	111.5	119.2	126.2	132.5	138.4	143.9	149.4	154.0
			57.5	70.5	81.5	90.5	98.5	105.5	112	117.5	123.5	138.5	133.5	137.5
38.20	30	.875	64.5	80.5	91.8	102.5	111.0	118.7	125.7	132	138.1	143.6	149.3	153.9
			56.5	70.0	81.0	90	97.5	105	111.5	117.0	123.0	127.5	133	137.0

XLIV—*Continued*

AMMONIA IN WATER

AND PER CENT NH_3 IN SOLUTION

Above One Standard Atmosphere												Specific Gravity.	Degrees Baumé.	Per Cent NH_3 by Weight.
60	65	70	75	80	85	90	95	100	105	110	115			
211.3	215.6	219.8	223.8	227.6	231.2	234.6	237.9	241.1	244.2	247.2	250.1	.928	21	19.87
209.5	214	218	221.5	225	229.5	233	236	239	242	245.5	248			
210.8	215.2	219.3	223.4	227.1	230.7	234.1	237.4	240.7	243.8	246.7	249.6	...	...	20
209	213.5	217.5	221	224.5	229	232.5	235.5	238.5	241.5	245	247.5			
207.1	211.5	215.6	219.7	223.3	227	230.4	233.7	237	240.1	243	245.9	...	...	21
205	209.5	213.5	217.5	221	224.5	227.5	231	234.5	237.5	240.5	243.5			
204.1	208.4	212.6	216.6	220.4	224	227.4	230.7	233.9	237	240	242.9	.921	22	21.75
202	206.5	210.5	214	218	221.5	225.5	228.5	232	234.5	237.5	240.5			
203.2	207.5	211.7	215.7	219.5	223.1	226.5	229.8	233	236.1	239.1	242	...	...	22
201	205.5	209.5	213	215	220.5	224.5	227	230.5	233	236.5	239.5			
199	203.3	207.5	211.5	215.3	218.9	222.3	225.6	228.8	231.9	234.9	237.8	.915	23	23.03
196.5	201.5	205	209	211	216.5	220	223	226.5	229	232.5	235			
195.8	200.1	204.2	208.3	212.1	215.7	219.1	222.4	225.6	228.7	231.7	234.6	...	...	24
193	197.5	201.5	205	207	212.5	216	219	222.5	225	228.5	231			
192.2	196.5	200.7	204.7	208.5	212.1	215.5	218.8	222	225.1	228.1	231	.909	24	24.99
188.5	193	197.5	201.5	205	208.5	212	215.0	218.5	221.5	224.5	227			
189.1	193.3	197.5	201.6	205.3	208.9	212.2	215.6	218.9	221.9	225	237.8	...	...	26
185.5	190	194	197.5	201.5	205	208	211.5	214.5	271.5	220.5	223.5			
185.9	190.2	194.3	198.4	202.2	205.7	209	212.5	215.8	218.7	221.8	234.7	...	...	27
181.5	186	190	194	197.5	201	204.5	207.5	210.5	213.5	216.5	219.5			
183.3	187.6	191.8	195.8	199.6	203.2	206.6	209.9	213.1	216.2	219.2	222.1	.904	25	27.66
179	183.5	187.5	191.5	195	198.5	202	205.5	208.5	211	214.5	217			
183.2	186.6	190.7	194.8	198.5	202.2	205.6	208.8	212.1	215.1	218.2	221.0	...	...	28
177.5	182	186.5	190	193.5	197.5	200.5	204	207	210	212.5	215.5			
180.2	183.5	187.6	191.8	195.4	199.1	202.6	205.7	209.0	212.1	215.1	217.9	...	...	29
174	178	182.5	186	190	193.5	196.5	200	203	206	209	211.5			
178.1	181.4	185.6	189.6	193.4	197.0	200.4	203.7	206.9	210	213.0	215.9	.898	26	29.60
171.5	176	180	184	187.5	191	194.5	198	201	203.5	207	209.5			
176.9	180.2	184.4	188.4	192.2	195.8	199.2	202.5	205.7	208.8	211.8	214.7	...	...	30
170	174.5	179	182.5	186	189.5	192.5	196.5	199.5	202.0	205	208			
173.5	177.0	181.2	185.2	189.0	192.6	196	199.3	202.5	206.6	209.6	212.5	.891	27	31.05
166.5	171	174.5	178.5	182.5	185.5	189	192.5	195.0	198.0	201	204.5			
170.9	174.4	178.6	182.6	186.4	190	193.4	196.7	199.9	204	207	209.9	...	...	32
163	167	167.5	175	178.5	182	185.5	188.5	192	194.5	197.5	200.5			
168.2	171.7	175.9	179.9	183.7	187.3	190.7	194.0	197.2	201.3	204.3	207.2	...	...	33
159.5	163.5	163.5	171.5	175	178.5	181.5	185	188	191.0	194	196.5			
157.3	170.8	175	179	182.8	186.4	189.8	193.1	196.3	200.4	203.4	206.3	.886	28	33.25
169.0	163	162.5	170.5	174.5	177.5	180.5	184	187.5	190	193	196.0			
165.4	168.9	173.1	177.1	180.9	184.5	187.9	191.2	195.4	198.5	201.5	204.4	...	...	34
156	160	160	168	171.5	175.5	178	181.5	184.5	187.5	190	193.0			
162.8	166.3	170.5	174.5	178.3	181.9	185.3	188.6	192.8	195.9	198.9	201.8	...	...	35
152.5	156.5	156.5	164	168	171.0	174	177.5	180.5	183.5	187	189.5			
161.2	164.7	168.9	172.9	176.7	180.3	183.7	187.0	191.2	194.3	197.3	200.2	.881	29	35.60
150.5	154.5	154.5	163	165.5	169	172	175.5	178.5	181.0	184.5	187			
160.8	164.5	168.7	172.7	176.5	180.1	183.5	186.8	191	193.9	196.9	199.8	...	...	36
149.0	153	153.0	160.5	160.5	167.5	170.5	174	177.0	179.5	182.5	185.5			
159.7	163.7	167.9	171.9	175.8	179.3	182.7	186.0	190.2	192.8	195.8	198.7	...	...	37
145.5	149.5	149.5	157	153	164.0	167	170.5	173	176.0	179.5	182.0			
158.6	162.9	167.1	171.1	175	178.5	181.9	185.2	189.4	191.7	194.7	197.6	...	...	38
142	146	146	153.5	150	160.5	163.5	166.5	170	172.5	175.5	178.5			
158.3	162.6	167	171.0	174.8	178.4	181.8	185.1	188.3	191.4	194.4	197.3	.875	30	38.20
141.5	145.5	145.5	153	149.5	160	163	166	169.5	172	175	178			

Table XLV

AMMONIA—WATER SOLUTIONS

VALUES OF PARTIAL PRESSURES OF AMMONIA AND WATER VAPOR FOR VARIOUS TEMPERATURES AND PER CENTS OF AMMONIA IN SOLUTION

Per cent NH_3	2.5				5.0				7.5			
Temperature ° F.	Partial Pressure of Ammonia Vapor.	Partial Pressure of Water Vapor.	Total Pressure Sum of Partials.	Total Pressure from New Standards.	Partial Pressure of Ammonia Vapor.	Partial Pressure of Water Vapor.	Total Pressure Sum of Partials.	Total Pressure from New Standards.	Partial Pressure of Ammonia Vapor.	Partial Pressure of Water Vapor.	Total Pressure Sum of Partials.	Total Pressure from New Standards.
	Press. Inches Hg				Press. Inches Hg				Press. Inches Hg			
32.	.236	.177	.413	..	.512	.158	.670	....	.788	.158	.946	..
35.6	.256	.197	.453	..	.571	.197	.768	....	.867	.197	1.064	..
39.2	.276	.236	.512	..	.591	.236	.827	....	.945	.216	1.161	..
42.8	.295	.276	.571	..	.650	.276	.926	....	1.041	.256	1.297	..
46.4	.315	.315	.630	..	.709	.315	1.024	....	1.16	.295	1.455	..
50.0	.354	.355	.709	..	.788	.355	1.343	....	1.28	.335	1.615	1.6
53.6	.394	.413	.807	..	.866	.394	1.260	....	1.415	.374	1.789	1.8
57.2	.434	.472	.906	..	.965	.452	1.417	....	1.575	.433	2.008	2.
60.8	.492	.532	1.024	..	1.062	.511	1.573	1.6	1.75	.473	2.223	2.1
64.4	.552	.590	1.142	..	1.18	.590	1.770	1.9	1.925	.552	2.477	2.5
68.	.611	.670	1.281	1.3	1.319	.649	1.958	2.	2.125	.611	2.736	2.9
71.6	.670	.748	1.318	1.5	1.455	.728	2.183	2.2	2.34	.689	3.029	3.1
75.2	.729	.847	1.576	1.6	1.592	.826	2.418	2.6	2.58	.788	3.368	3.6
78.8	.807	.945	1.752	1.8	1.75	.925	2.675	2.8	2.835	.866	3.701	3.9
82.4	.885	1.06	1.945	2.	1.925	1.043	2.968	3.	3.09	.985	4.075	4.1
86	.985	1.2	2.185	2.1	2.125	1.180	3.305	3.5	3.49	1.122	4.612	4.8
89.6	1.085	1.36	2.445	2.5	2.30	1.34	3.64	3.8	3.70	1.28	4.98	5.2
93.2	1.18	1.515	2.695	2.8	2.52	1.495	4.015	4.1	4.06	1.435	5.495	5.8
96.8	1.28	1.69	2.97	3	2.725	1.672	4.397	4.5	4.42	1.615	6.035	6
100.4	1.38	1.89	3.27	3.4	3.01	1.870	4.880	5	4.82	1.81	6.63	6.7
104.0	1.455	2.125	3.580	3.8	3.29	2.085	5.375	5.2	5.27	2.03	7.30	7.3
107.6	1.655	2.36	4.015	4	3.58	2.30	5.88	6	5.72	2.245	7.965	8
111.2	1.811	2.62	4.431	4.6	3.90	2.56	6.46	6.5	6.18	2.50	8.68	8.8
114.8	1.970	2.95	4.920	5	4.23	2.815	7.045	7	6.78	2.76	9.54	9.4
118.4	2.15	3.21	5.36	5.2	4.58	3.11	7.69	7.8	7.33	3.05	10.38	10.2
122.0	2.320	3.54	5.860	5.9	4.96	3.44	8.40	8.5	7.89	3.37	11.26	11.3
125.6	2.520	3.88	6.400	6.4	5.35	3.80	9.15	9	8.55	3.70	12.25	12.
129.2	2.740	4.29	7.030	7	5.80	4.22	10.02	10.	9.25	4.07	13.32	13.2
132.8	2.955	4.73	7.685	7.8	6.25	4.65	10.90	11	9.89	4.5	14.39	14.4
136.4	3.15	5.21	8.36	8.2	6.72	5.12	11.84	12	10.06	4.98	15.04	15.8
140	3.37	5.77	9.14	9	7.2	5.63	12.83	12.9	11.45	5.49	16.94	16.9

	10				12.5				15			
32	1.21	.158	1.368	1	1.58	.138	1.718	1.5	2.11	.138	2.248	2
35.6	1.24	.177	1.417	1.5	1.72	.157	1.877	1.8	2.3	.157	2.457	2.5
39.2	1.36	.197	1.557	1.5	1.89	.177	2.067	2.1	2.54	.177	2.717	2.8
42.8	1.495	.236	1.731	1.7	2.09	.217	2.307	2.5	2.79	.217	3.007	3
46.4	1.67	.276	1.946	1.9	2.31	.256	2.566	2.8	3.07	.256	3.326	3.2
50	1.87	.315	2.185	2	2.56	.295	2.855	3	3.41	.295	3.705	3.8
53.6	2.05	.355	2.405	2.4	2.82	.335	3.155	3.3	3.76	.335	4.095	4.1
57.2	2.28	.413	2.693	2.9	3.12	.394	3.514	3.7	4.14	.374	4.514	4.7
60.8	2.52	.472	2.992	3	3.45	.453	3.903	4	4,55	.433	4.983	5
64.4	2.79	.532	3.322	3.4	3.82	.512	4.332	4.5	5.02	.492	5.512	5.5

TABLE XLV—*Continued*

Per cent NH_3	10				12.5				15			
Temperature ° F.	Partial Pressure of Ammonia Vapor.	Partial Pressure of Water Vapor.	Total Pressure Sum of Partials.	Total Pressure from New Standards.	Partial Pressure of Ammonia Vapor.	Partial Pressure of Water Vapor.	Total Pressure Sum of Partials.	Total Pressure from New Standards.	Partial Pressure of Ammonia Vapor.	Partial Pressure of Water Vapor.	Total Pressure Sum of Partials.	Total Pressure from New Standards.
	Press. Inches Hg				Press. Inches Hg				Press. Inches Hg			
68	3.09	.590	3.680	3.8	4.22	.571	4.791	5	5.55	.552	6.102	6
71.6	3.4	.670	4.070	4	4.61	.65	5.26	5.4	6.1	.631	6.731	7.7
75.2	3.74	.767	4.507	4.6	5.04	.729	5.769	6	6.7	.71	7.41	7.6
78.8	4.09	.847	4.937	5	5.55	.827	6.377	6.6	7.33	.81	8.14	8
82.4	4.49	.965	5.455	5.4	6.08	.926	7.006	7	7.98	.906	8.886	8.9
86	4.9	1.1	6.0	6.1	6.66	1.04	7.70	7.8	8.66	1.005	9.665	9.9
89.6	5.35	1.24	6.59	6.8	7.26	1.18	8.44	8.5	9.5	1.12	10.62	10.7
93.2	5.86	1.4	7.26	7.4	7.92	1.32	9.24	9.3	10.35	1.26	11.61	11.9
96.8	6.37	1.555	7.925	7.9	8.63	1.47	10.10	10	11.28	1.42	12.70	12.8
100.4	6.94	1.75	8.69	8.8	9.38	1.67	11.05	11	12.25	1.59	13.84	13.9
104.0	7.5	1.95	9.45	9.5	10.18	1.87	12.05	12	13.22	1.77	14.99	15
107.6	8.19	2.165	10.355	10.4	11.02	2.07	13.09	13	14.30	1.98	16.28	16.3
111.2	8.88	2.42	11.30	11.4	11.9	2.32	14.22	14.4	15.45	2.2	17.65	17.8
114.8	9.6	2.68	12.28	12.2	12.88	2.56	15.44	15.7	16.62	2.44	19.06	19
118.4	10.38	2.97	13.35	13.3	13.85	2.83	16.68	17	17.9	2.69	20.59	20.6
122.0	11.22	3.25	14.47	14.5	14.95	3.13	18.08	18	19.3	2.97	22.27	22.2
125.6	12.05	3.58	15.63	15.5								
129.2	12.95	3.96	16.91	17								
132.8	13.95	4.37	18.32	18.2								
136.4	15.0	4.81	19.81	20								
140	16.5	5.29	21.79	21.2								

	17.5				20				22.5			
32	2.72	.138	2.858	2.8	3.46	.118	3.578	3.5	4.37	.118	4.488	4.6
35.6	3.0	.157	3.157	3.1	3.84	.138	3.978	4	4.85	.138	4.988	5
39.2	3.29	.177	3.467	3.5	4.22	.158	4.378	4.3	5.33	.158	5.488	5.9
42.8	3.62	.217	3.837	3.9	4.65	.177	4.827	4.9	5.86	.177	6.037	7
46.4	4.02	.256	4.276	4.2	5.12	.217	5.337	5.1	6.43	.197	6.627	6.7
50	4.41	.295	4.705	4.8	5.63	.256	5.886	5.9	7.07	.236	7.306	7.3
53.6	4.87	.335	5.205	5.2	6.2	.295	6.495	6.4	7.74	.275	8.015	8
57.2	5.36	.374	5.734	5.9	6.8	.335	7.135	7.1	8.48	.315	8.795	9
60.8	5.92	.433	6.353	6.5	7.49	.394	7.884	7.8	9.3	.354	9.654	9.7
64.4	6.5	.492	6.992	7	8.2	.453	8.653	8.6	10.18	.394	10.574	10.8
68	7.13	.552	7.682	7.8	9.0	.512	9.512	9.5	11.12	.453	11.573	12
71.6	7.8	.631	8.431	8.5	9.85	.571	10.421	10.3	12.15	.512	12.662	12.9
75.2	8.55	.71	9.26	9.3	10.75	.65	11.40	11.5	13.25	.571	13.821	14
78.8	9.33	.788	17.118	10.3	11.75	.73	12.48	12.4	14.45	.65	15.10	15.2
82.4	10.2	.866	11.066	11.4	12.75	.85	13.60	13.6	15.85	.729	16.579	17
86	11.1	.966	12.066	12	13.9	.905	14.805	15	17.40	.807	18.207	18
89.6	12.1	1.08	13.18	13.3	15.05	1.14	16.19	16.1				
93.2	13.2	1.22	14.24	14.5	16.30	1.26	17.56	17.9				
96.8	14.35	1.36	15.71	15.8	17.75	1.4	19.15	18.9				
100.4	15.6	1.5	17.1	17	19.35	1.55	20.90	20.6				
104.0	16.95	1.67	18.62	18.6	21.05	1.71	22.76	22.3				
107.6	18.45	1.85	20.30	19.9								

TABLE XLVI

ABSORPTION OF GASES BY LIQUIDS

Selected from Smithsonian Physical Tables.

Values of x_t=volume of gases referred to 32° F. and 29.92 ins. Hg which one volume of water can absorb at atmospheric pressure and temperature of first column.

Temperature.		CO_2.	CO.	H.	N.	O.	Air.	NH_3.	H_2S.	Methane.	Ethylene.
° C.	° F.										
0	32	1.797	.0354	.02110	.02399	.04925	.02471	1174.6	4.371	.04573	.2563
5	41	1.450	.0315	.02022	.02134	.04335	.02179	971.5	3.965	.04889	.2153
10	50	1.185	.0282	.01944	.01918	.03852	.01953	840.2	3.586	.04367	.1837
15	59	1.002	.0254	.01875	.01742	.03456	01795	756.0	3.233	.03903	.1615
20	68	.901	.0232	.01809	.01599	.03137	.01704	683.1	2.905	.03499	.1488
25	77	.772	.0214	.01745	.01481	.02874	.....	610.8	2.604	.02542	....
30	86	....	.0200	.01690	.01370	.02646	.....	....	....	.....	....
40	104	.506	.0177	.01644	.01195	.02316	.....	.....	....	.....	....
50	122	....	.0161	.01608	.01074	.02080	.....	....	....	.....	....
100	212	.244	.0141	.01600	.01011	.01690	.....	....	....	.....	....

TABLE XLVII

ABSORPTION OF AIR IN WATER (WINKLER, 1904)

Air free of CO_2 and NH_3 measured at 29.92 ins. and 32° F.

Temperature. ° C.	Cu.ft. Oxygen at 29.92 ins. Hg per 1000 cu.ft. water.	Cu.ft. Nitrogen per 1000 cu.ft. water.	Sum of Oxygen and Nitrogen.	Temperature. ° C.	Cu.ft. Oxygen at 29.92 ins. Hg per 1000 cu.ft. water.	Cu.ft. Nitrogen per 1000 cu.ft. water.	Sum of Oxygen and Nitrogen.
0	10.19	18.99	29.18	16	6.89	13.25	20.14
1	9.91	18.51	28.42	17	6.75	13.00	19.75
2	9.64	18.05	27.69	18	6.61	12.77	19.38
3	9.39	17.60	26.99	19	6.48	12.54	19.02
4	9.14	17.18	26.32	20	6.36	12.32	18.68
5	8.91	16.77	25.68	21	6.23	12.11	18.34
6	8.68	16.38	25.06	22	6.11	11.90	18.01
7	8.47	16.00	24.47	23	6.00	11.69	17.69
8	8.26	15.64	23.90	24	5.89	11.49	17.38
9	8.06	15.30	23.36	25	5.78	11.30	17.08
10	7.87	14.97	22.84	26	5.67	11.12	16.79
11	7.68	14.65	22.33	27	5.56	10.94	16.50
12	7.52	14.35	21.87	28	5.46	10.75	16.21
13	7.35	14.06	21.41	29	5.36	10.56	15.92
14	7.19	13.78	20.97	30	5.26	10.38	15.64
15	7.04	13.51	20.55				

TABLE XLVIII

AIR REQUIRED FOR COMBUSTION FOR VARIOUS SUBSTANCES

(Combustion complete in every case except for C burning to CO)

Substance		1 Lb. of Substance Requires Air		1 Cu. Ft. of Substance (Standard) Requires Air	
		Lbs.	Cu.Ft. Standard	Lbs.	Cu.Ft. Standard.
Carbon,	C to CO_2	11.55	143.10		
Carbon,	C to CO	5.77	71.55		
Hydrogen,	H_2	34.64	429.19	.193	2.39
Carbon monoxide,	CO	2.47	30.6	.193	2.39
Sulphur,	S	4.32	53.52		
Methane,	CH_4	17.32	214.59	.774	9.59
Ethane,	C_2H_5	16.16	200.22	1.354	16.73
Ethylene,	C_2H_4	14.85	183.99	1.157	14.34
Acetylene,	C_2H_2	13.32	165.07	.964	11.95
Propane,	C_3H_8	15.75	195.14	1.929	23.90
Propylene,	C_3H_6	14.85	183.99	1.736	21.51
Allylene,	C_3H_4	13.86	172.73	1.543	19.12
Butane,	C_4H_{10}	15.53	192.42	2.508	31.07
Butylene,	C_4H_8	14.85	183.99	2.315	28.68
Pentylene,	C_5H_{10}	14.85	183.99	2.890	35.85
Hexane,	C_6H_{14}	15.22	188.58	3.66	45.45
Benzole,	C_6H_6	13.32	165.07	2.89	35.84
Heptane,	C_7H_{16}	15.24	188.85	4.243	52.58
Methyl alcohol,	CH_3OH	6.49	80.47	.58	7.17
Ethyl alcohol,	C_2H_5OH	9.04	111.96	1.17	14.34

TABLE XLIX

RADIATION COEFFICIENTS

	Radiating and Absorbing Powers.	Reflecting Power.
Porous carbon (black body)	1.00	0.00
Glass	.90	.10
Ice	.85	.15
Polished cast iron	.25	.75
Wrought iron polished	.23	.77
Steel polished	.19	.81
Brass polished	.07	.93
Copper hammered	.07	.93
Silver polished	.03	.97

TABLE L

COEFFICIENTS OF HEAT TRANSFER

AVERAGE PRACTICE

Thermal Action in Substances. Giving Up Heat.	Thermal Action in Substances. Receiving Heat.	B.T.U. per Hour per Square Foot per Degree.	Apparatus.
Liquid cooling	Liquid warming	50–75	Liquid heat exchangers, aqua ammonia water and beer coolers, ammonia absorber cooling coils
	Gas warming	2–6	Hot-water radiators and cooling tower surfaces, depending on air velocity and character of water surface
	Liquid boiling	100 10–20 30–50	Shell brine coolers with circulator; tank brine coolers without circulator; double pipe brine coolers depending on velocity and hot liquid evaporators
Gas cooling	Liquid warming	2–5	Brine coolers in cold storage rooms depending on air circulation. Air coolers with water or brine coils; economizers
	Gas warming	2–4	Steam superheaters
	Liquid boiling	2–5	Direct expansion ammonia coils in cold storage rooms depending on air circulation. Steam boilers
Vapor condensing	Liquid warming	150–350 1000	Feed-water heaters and steam condensers depending on water velocity and removal of air on steam side. Experimental feed-water heater high velocity
	Gas warming	2–4	Steam radiators and pipes
	Liquid boiling	400–600	Vacuum evaporators with condensing exhaust steam depending on viscosity of solution

TABLE LI

HEATS OF COMBUSTION OF FUEL ELEMENTS AND CHEMICAL COMPOUNDS, SELECTED FROM LANDOLT AND BÖRNSTEIN, MEYERHOFFER AND SMITHSONIAN TABLES AND THOMSEN'S THERMO-CHEMISTRY

Substance.	Products.	B.T.U. per Lb.	Authority for B.T.U. per Lb.	Cu.ft. per Lb. at 32° F. and 29.92 ins. Hg.	Authority for Volume.	B.T.U. per Cu.ft. at 32° F. and 29.92 ins. Hg.
Carbon, C	CO_2	14544	Favre and Silberman			
Carbon, C	"	14647	Berthelot			
Graphite, C	"	14222	Berthelot			
Graphite, C	"	14033	Favre and Silberman			
Diamond, C	"	14146	Berthelot			
Carbon, soft, C	CO	4451	Favre and Silberman			
	"	4480	Berthelot			
	"	4351	Calc. from Thomsen			
Hydrogen, H_2	H_2O liquid 64° F.	61200	Thomsen	177.9093	Rayleigh	344
	" 90° F.	60854	Andrews			
	" 64° F.	61477	Favre and Silberman			
	" 212° F.	60626	Calc. from Thomsen			341
	vapor 212° F.	51892	Calc. from Thomsen			292
	" 212° F.	51717	Favre and Silberman			
Carbon monoxide, CO:	CO_2	4369	Thomsen	12.8090	Ledoux	341
	"	4325	Favre and Silberman			338
	"	4376	Andrews			341
Sulphur, S:	SO_2 gas	3998	Thomsen			
	" "	3897	Berthelot			
	SO_3 liquid	5810	Thomsen			
Methane, CH_4:	CO_2 and H_2O liquid 64° F.	23841	Thomsen	22.349	Thomsen	
	" " 64	24017	Berthelot			
	" " 212	23646	Calc. from Thomsen			1066
	" vapor 212	21463	Calc. from Thomsen			959

TABLE LI—*Continued*

HEATS OF COMBUSTION OF FUEL ELEMENTS AND CHEMICAL COMPOUNDS, SELECTED FROM LANDOLT AND BÖRNSTEIN, MEYERHOFFER AND SMITHSONIAN TABLES AND THOMSEN'S THERMO-CHEMISTRY

Substance.	Products.	B.T.U. per Lb.	Authority for B.T.U. per Lb.	Cu.ft. per Lb. at 32° F. and 29.92 ins. Hg.	Authority for Volume.	B.P.U. per Cu.ft. at 32° F. and 29.92 ins. Hg.
Pentylene, C_5H_{10}:	CO_2 and H_2O liquid 64	20674	Favre and Silberman	5.08	Avogadro's Law †	
	" " 212 *	20516	Calc. from F. &. S			4039
	" vapor 212	19268	Calc. from F. & S.			3793
Hexane, C_6H_{14}:	" liquid 64	20745	Stoleman	4.14	"	
	" " 212	20610	Calc. from Stoleman			4970
	" vapor 212	19195	Calc. from Stoleman			4630
Benzole, C_6H_6:	" liquid 64	18094	Berthelot	4.56	"	
	" " 212	17976	Calc. from Berthelot			3942
	" vapor 212	17305	Calc. from Berthelot			3795
Heptane, C_7H_{16}:	" liquid 64	20741	Stoleman	3.56	"	
	" " 212	20640	Calc. from Stoleman			5797
	" vapor 212	19230	Calc. from Stoleman			5400
Methyl alcohol, CH_3OH:	" liquid 64	10250	Thomsen	11.12	"	
	" " 64	9596	Berthelot			
	" " 212	10203	Calc. from Thomsen			917
	" vapor 212	9113	Calc. from Thomsen			819
Ethyl alcohol, C_2H_5OH:	" liquid 64	13325	Thomsen	7.73	"	
	" " 64	12748	Berthelot			
	" " 212	13246	Calc. from Thomsen			1720
	" vapor 212	12100	Calc. from Thomsen			1570

* The value at 212° F. based on specific heat calculated by means of atomic weight.
† Approximate molecular weights used.

TABLE LII

INTERNAL THERMAL CONDUCTIVITY

Adapted from Landolt, Börnstein, Meyerhoffer, and Smithsonian Physical Tables and Professional Papers.

Substance.	Small Calories per Second per Sq.cm. per Degree C. per Cm. Thick.	B.T.U. per Hour per Sq.ft. per Degree F. per Inch Thick = K.	Authority.
Iron	$.1665(1-.000228t)$	$483\ [1-.000127(t-32)]$	Lorenz
	$.209(1-.00147t)$	$606\ [1-.00082(t-32)]$	Forbes
	$.197(1-.00002t)$	$571\ [1-.0000111(t-32)]$	Tait
	$.175(1-.0015t)$ ←	$507\ [1-.00083(t-32)]$	Stewart
	$.199(1-.00287t)$	$577\ [1-.00159(t-32)]$	Augstrom
	.1528 at 28° C.	443 at 82° F.	Hall
	.1627 at 100° C.	472 at 212° F.	Lorenz
Copper	$.7189(1+.000051t)$ ←	$2080[1+.0000278(t-32)]$	Lorenz
	$.71\ (t+.0014t)$	$2060[1+.000788(t-32)]$	Tait
	$1.08\ (1+.0013t)$	$3130[1+.000722(t-32)]$	Tait
	$1.027\ (1-.00214t)$	$2980[1-.00119(t-32)]$	Augstrom
	$.983\ (1-.00152t)$	$2850[1-.000845(t-32)]$	Augstrom
	$1.12\ (1-.001t)$	$3250[1-.00055(t-32)]$	Stewart
Brass, Yellow	$.2041(1+.002445t)$	$592\ [1+.00136(t-32)]$	Lorenz
Brass, Red	$.2460(1+.001492t)$	$713\ [1+.000892(t-32)]$	Lorenz
Steel, Hard	.0620	180.0	Kohlrausch
Steel, Soft	.1110 ←	322.0	Kohlrausch
Steel, Bessemer	.0964 at 15° C.	279.5	Kirchhoff
Aluminum	$.3435(1+.0005356t)$	$966\ [1+.0002980(t-32)]$	Lorenz
Lead	$.0836(1-.000861t)$	$242.5[1-.000479(t-32)]$	Lorenz
Tin	$.1528(1-.000687t)$	$443\ [1-.000382(t-32)]$	Lorenz
Zinc	.1528 at 15° C. ←	443	Kirchhoff and Hansem
Zinc	.2653 at 18° C.	770	Jaeger and Diesselhorst
Silver (highest of all)	1.0960	3180	Weber

The → indicates direct measurements which correspond most closely to the probable real value.

TABLE LII—*Continued*

Substance.	Small Calories per Second per Sq.cm. per Degree C. per Cm. Thick.	B.T.U. per Hour per Sq.ft. per Degree F. per Inch Thick $=K$.	Authority.
Slate	.0036	9.58	Lees Chorlton
Granite and sandstone	.0054	15.65	Average
Marble, limestone, etc.	.0047 to .0056	13.6–16.2	Herschel, Lebour, Dunn
Portland cement	.00071	2.06	Lees Chorlton
Plaster of Paris	.0007	2.03	Lees Chorlton
Soil	.00033 dry: .0016 wet	.958 dry; 4.64 wet	Lees Chorlton
Sand, white dry	.00093	2.7	Herschel, Lebour, Dunn
Chalk	.0002	.58	Herschel, Lebour, Dunn
Firebrick	.00028	.812	Hutton, Bland
Carbon	.000405	1.32	Forbes
Glass	.0011 to .0023	3.19 to 6.68	Averages
Diatomic earth	.00013	.377	Hutton, Bland
Paraffine	.00023 at 0° C. and .00168 at 100° C.	.667 at 0° C. and 4.88 at 100° C.	Weber
Ice	.00223; .00568	6.47; 16.48	Forbes, Newman
Snow, packed	.00051	1.48	Hjeltström
Sawdust	.00012	.348	Forbes
Woods	.0003 with grain, .00009 across grain	.871 with grain, .0261 across grain	Forbes
Strawboard	.0003	.871	Forbes
Pasteboard	.00045	1.305	Forbes
Asbestos paper	.00043	1.245	Lees Chorlton
Blotting paper	.00015	.435	Lees Chorlton
Felt	.000087	.252	Forbes
Cotton wool	.000043	.125	Forbes
Cotton wool pressed	.000033	.0957	Forbes
Flannel	.00012	.348	Forbes
Haircloth	.000042	.122	Forbes
Cork	.000717	2.08	Forbes
Leather, cowhide	.00042	1.22	Lees Chorlton

TABLE LII—*Continued*

Substance.	Small Calories per Second per Sq.cm. per Degree C. per Cm. Thick.	B.T.U. per Hour per Sq.ft. per Degree F. per Inch Thick $=K$.	Authority.
LIQUIDS			
Water	.00120 at 0° C.	3.48	Weber
	.00136 from 9° C. to 15	3.94	Weber
	.00129 at 4° C.	3.74	Wachsmuth
	.00124 at 18° C.	3.6	Chree
	.00157 at 30° C.	4.56	Graetz
	.00222 at 108° C.	6.45	Lundquist
Methyl alcohol	.000495 from 9° C. to 15	1.435	Weber
Ethyl alcohol	.000423 from 9° C. to 15	1.22	Weber
Ethyl alcohol and water 50%	.0008 at 25° C.	2.32	Lees
Benzole	.000333 from 0° C. to 15	.972	Weber
Petroleum	.000355 at 13° C.	1.03	Graetz
GASES			
Air	$.0000568(1+.0019t)$	$.165[1+.000106(t-32)]$	Winkelmann
	.0000484	.1405	Graetz
	.0000569	.165	Schwarze
	.000072	.209	Schleiermacher
Ammonia	$.0000389(1+.0026t)$	$.113\ [1+.00144(t-32)]$	Schwarze
Ethylene	$.0000395(1+.00445t)$	$.1145[1+.00248(t-32)]$	Winkelmann
Hydrogen	$.000327\ (1+.00175t)$	$.95\ [1+.000974(t-32)]$	Winkelmann
Hydrogen	.000319 at 0° C.	.926	Eckerlein
Nitrogen	.0000524 from 7° C. to 8	.152	Winkelman
Oxygen	.0000563 from 7° C. to 8	.163	Winkelmann
Methane	.0000647	.188	Winkelmann
Carbon monoxide	.0000499 at 0° C.	.145	Winkelmann
Carbon dioxide	.0000307 at 0° C.	.0891	Winkelmann

Table LIII

RELATIVE THERMAL CONDUCTIVITY

Conductivities Carbon Dioxide and Resistances Silver $\} = 1$ at 32° F.

Substance.	Conductivity Carbon Dioxide = 1.	Resistance $= \frac{1}{\text{Conductivity}}$ Silver = 1.
Iron	5700	5.23
Iron (Wiederman and Franz)	4165	8.60
Copper	23000	1.52
Copper (Wiederman and Franz)	25760	1.36
Steel	3600	9.74
Steel (Wiederman and Franz)	4165	8.60
Aluminum	11000	3.18
Lead	2700	12.95
Lead (Wiederman and Franz)	2975	11.75
Tin	5000	7
Tin (Wiederman and Franz)	5320	6.58
Zinc	5000	7
Zinc (Wiederman and Franz)	9835	3.56
Silver	35000	1
Slate	117	300
Granite and sandstone	176	199
Marble, limestone, etc	153–182	228–192
Portland cement	23.2	1511
Plaster of Paris	22.8	1531
Soil	10.7 dry; 52.2 wet	3270 dry; 6700 wet
Sand, white dry	30.4	1150
Chalk	6.52	5370
Firebrick	9.12	3840
Carbon	13.2	2650
Glass	35.8 to 75	978 to 467
Diatomic earth	4.24	8260
Paraffine	7.50 at 0° C. to 55.0 at 100° C.	4670 at 32° F. to 637 at 212°
Ice	72.7; 18.5	481; 189.0
Sawdust	3.92	8940
Snow, packed	16.6	2110
Woods	9.8 w.g.; 2.94 a.g.	3570 with grain; 11900 ac.gr.
Strawboard	9.8	3570
Pasteboard	14.7	2380
Asbestos paper	14.0	2500
Blotting paper	4.9	7150
Felt	2.84	12300
Cotton wool	1.4	25000

TABLE LIII—*Continued*

RELATIVE THERMAL CONDUCTIVITY

Substance.	Conductivity Carbon Dioxide = 1.	Resistance = $\frac{1}{\text{Conductivity}}$ Silver = 1.
Cotton wool, pressed	1.08	32400
Flannel	3.92	8930
Haircloth	1.37	25600
Cork	2.34	1495
Leather, cowhide	13.7	2560
Water	39.09	896
Methyl alcohol	16.12	2170
Methyl alcohol (De Heen)	10.70	3270
Ethyl alcohol	13.78	2540
Ethyl alcohol (Henneberg)	12.07	2900
Ethyl alcohol 90% (Henneberg)	12.53	2990
Ethyl alcohol (Henneberg)	21.22	1650
Benzole	10.83	3240
Benzole (Weber)	11.25	3100
Petroleum	11.56	3030
Air	1.85	18900
Ammonia	1.27	27600
Ammonia (Plank)	1.7	20600
Ethylene	1.28	27400
Ethylene	1.37	2960
Hydrogen	10.65	3280
Hydrogen (Stefan)	12.97	2960
Hydrogen (Kindt and Warberg)	13.14	7100
Nitrogen	1.71	20450
Oxygen	1.83	19100
Oxygen (Stefan)	1.89	25500
Methane	2.30	15200
Methane (Stefan)	2.57	18500
Carbon monoxide	1.62	21600
Carbon monoxide (Kindt and Warberg)	1.81	19300
Carbon dioxide	1.00	35000
Carbon dioxide (Stefan)	1.15	30400
Carbon dioxide (Kindt and Warberg)	1.09	32100
Illuminating gas (Plank)	4.94	13600

TABLE LIV

COMPARISON OF CELLULOSE AND AVERAGE WOOD (DRY AND ASH FREE)

Constituent.	Cellulose.	Wood, Average of Maple, Oak, Pine, Willow.	Spores of Club Moss.
Carbon	44.44%	49.2%	63.0%
Hydrogen	6.17%	6.1%	8.6%
Oxygen	49.39%	....	....
Oxygen and nitrogen	....	44.7%	28.4%

Table LV

COMPOSITION AND CALORIFIC POWER OF CHARACTERISTIC COALS

No.	Name, Source, Size, Authority.	Total C / Total H	Proximate.				Ultimate.						B.T.U. per Lb.	
			% Moisture.	% Volatile.	% Fixed C.	% Ash.	% H_2.	% C.	% N_2.	% O_2.	% S.	% Ash.	By Calorimeter.	By Calculation.
1	Anth. de la Mare, Grand Couche, France, Mahler	63.3	4.4	2.5	88.4	4.7	1.37	86.56	...	2.97	...	4.7	13442	13420
2	Pa. anth., Treverton, Isherwood	52.31	.84	6.67	85.66	6.83	1.73	90.66	...	.78	...	6.83	14025	14235
3	Anth. Pennsylvania, Mahler	43.35	3.45	2.72	87.92	5.9	2.00	86.46	...	2.2	...	5.9	13471	13787
4	Anth. Hay-Daong (Tonkin), France, Mahler	43.00	3.26	2.24	89.8	4.00	2.00	86.11	...	4.47	...	4.00	13559	13736
5	Bit. Pa., Ormsby, U. S. A., Isherwood	35.5	1.25	39.03	53.72	6.00	2.47	87.57	1.04	2.67	...	6.00	13901	14034
6	Anth. Keban, France, Mahler	30.44	2.8	4.78	86.79	5.45	2.73	85.75	...	2.73	...	5.45	14090	14124
7	Anth. Commentry, France, Mahler	29.32	1.78	2.97	89.87	5.4	2.89	84.93	...	5.00	...	5.4	14130	14104
8	Anth. Blanzy, Ste. Barbe, France, Mahler	28.40	1.76	5.52	56.42	6.3	2.92	82.75	...	6.28	...	6.3	13991	13805
9	Pa. anth., culm, Scranton, U.S.G.S., No. 3	26.7	2.08	2.27	74.32	16.33	2.81	75.21	.80	4.08	.77	16.33	12472	12673
10	Anth. Creusot, France, Mahler	24.4	1.8	10.10	86.65	1.45	3.66	89.39	...	3.7	...	1.45	15127	15220
11	Anth., Grande Combe, Purts Petassus, Fr., Mahler	23.15	.83	11.16	85.74	7.25	3.63	84.07	...	4.22	...	7.25	14130	14428
12	Ruhr coal, Hörde, Germany, Bunte	21.75	.8	13.04	76.32	9.84	3.68	80.08	4.	11*	1.49	9.84	13468	12937
13	Ruhr coal, Bickefeld, Germany, Bunte	21.68	.8	13.23	81.99	3.98	4.04	85.63	3.	56*	1.99	3.98	14539	14983
14	Semi-fat d'Anzin, Fosse St. Marc, France, Mahler	21.37	1.35	13.79	84.16	1.7	4.14	88.47	4.	34*	...	1.7	15106	15377
15	Semi-anth., Coalhill, Ark., Spadra Bed, U.S.G.S., No. 5	20.7	1.28	12.82	73.69	12.21	3.74	77.29	1.39	3.36	2.01	12.21	13406	13589
16	Semi-fat, Roche-la-Moliere, France, Mahler	20.57	.9	13.39	82.26	4	4.17	85.69	...	5.24	...	4	15151	14991
17	Semi-fat, Aniche, France, Mahler	20.48	.63	11.38	83.99	4	4.2	85.93	...	5.24	...	4	15668	15044
18	Semi-fat, Grande Combe, France, Mahler	20.45	6.1	12.79	82.80	3.8	4.27	87.16	...	4.16	...	3.8	15058	15265
19	Ruhr coal, Fröhlich Morgensonne, Ger., Bunte	20.27	.7	14.12	83.55	1.63	4.41	89.27	2.	74*	1.25	1.63	15194	15707
20	Semi-bit. Pocahontas r. of m., W. Va., Lord & Haas	20.27	.8	18.30	73.65	7.25	4.13	83.75	.85	2.65	.57	7.25	14512	14707
21	Semi-bit. r. of m., Pochontas, Va., Lord & Haas	20.11	.63	18.62	75.12	5.63	4.25	85.46	.85	3.24	.57	5.63	14733	15029
22	Same	19.84	.8	18.30	73.65	7.25	4.22	83.75	.85	3.36	.57	7.25	14512	14762
23	Same coal bed, Zenith, W. Va., U.S.G.S., No. 11	19.60	.8	16.90	70.80	11.50	4.03	79.12	1.04	3.78	.53	11.50	13970	13972
24	Bituminous r. of m., Windber, Pa., U.S.G.S., No. 1	19.50	1.10	15.80	75.69	7.41	4.20	81.98	1.36	3.56	1.49	7.41	14499	14529
25	Pocahontas run-of-mine, Lord & Haas	19.45	.85	18.60	75.75	4.80	4.39	85.40	.85	3.94	.62	4.80	14906	15112
26	Ruhr coal, Dannenbaum, Germany, Bunte	19.32	1.84	21.04	73.97	3.15	4.38	85.18	4.	39*	1.06	3.15	14544	14968

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27	Bit. lump, Huntington Bed, Bonanza, Ark., U.S.G.S. No. 2	19.30	.74	16.26	73.66	9.34	4.13	80.03	1.40	3.20	1.90	9.34	13961	14220
28	Semi-bit. r. of m. Pocahontas, Big Sand, W. Va., U.S.G.S. No. 12	19.20	.62	18.05	74.38	6.95	4.36	83.63	1.34	3.03	.69	6.95	14733	14834
29	Fat, Anzin, France, Mahler	19.10	1.1	20.19	73.70	5	4.39	83.75	...	5.76	...	5	14492	14842
30	Bit. lump and nut, Huntington, Ark., U.S.G.S., No. 1	18.90	1.17	17.38	68.12	12.88	4.00	75.68	1.47	4.70	1.27	12.88	13410	13483
31	Bit. lump and slack, Huntington, Jenny Lind, Ark., U.S.G.S. No. 3	18.80	.8	19.75	67.65	11.80	4.07	76.37	1.55	4.91	1.30	11.80	13655	13626
32	Semi-bit., r. of m., New River Bed, Sun, W. Va., U.S.G.S. No. 7	18.80	.76	20.54	73.61	5.09	4.38	82.41	1.05	5.87	1.20	5.09	14857	14689
33	Ruhr coal, Bonifacius, Germany, Bunte	18.78	1.09	16.64	75.67	6.60	4.23	79.60	6.	77*	1.71	6.60	13567	14191
34	Fat, Lens, France, Mahler	18.75	1	19	78.45	1.55	4.68	87.74	...	5.03	...	1.55	15505	15600
35	Semi-bit., r. of m., Pocahontas field, Mora, W. Va., U.S.G.S. No. 10	18.70	.65	18.80	75.92	4.63	4.58	85.91	4.07	3.24	.57	4.63	15190	15297
36	Fat, Roche-la-Moliere, France, Mahler	18.47	1.35	21.86	73.79	3	4.63	85.64	...	5.39	...	3	15268	15263
37	Fat, Rouchamp, France, Mahler	18.36	1.2	20.70	68.39	9.7	4.31	79.2	...	5.59	...	9.7	14102	14132
38	Bituminous, Cumberland, Md., Isherwood	18.21	1.25	13	80.75	5	4.75	86.5	...	2.5	...	5	15300	15460
39	Ruhr coal, Oberhausen, Germany, Bunte	18.20	.57	17.32	71.96	10.15	4.36	79.30	4.	66*	.96	10.15	13536	14176
40	Ruhr coal, Mathias Stinnes, Germany, Bunte	18.17	1.28	19.99	71.70	7.03	4.49	81.65	4.	02*	1.53	7.03	14116	14597
41	Ruhr coal, Lothringen, Germany, Bunte	18.15	1.49	22.23	72.19	4.09	4.55	82.63	6.	22*	1.02	4.09	14112	14775
42	Fat, Carmaux, France, Mahler	18.04	1.5	21.10	75.90	1.5	4.72	85.2	7.	07*	...	1.5	15084	15252
43	Fat, Mines des Ports (Gard), France, Mahler	17.92	.77	17.42	72.89	8.91	4.37	78.24	4.	7*	...	8.91	13763	14028
44	Semi-bit. r. of m., New River Bed, Rush Run, W. Va., U.S.G.S. No. 6	17.80	.64	21.74	72.53	5.09	4.70	83.62	1.70	4.23	.66	5.09	14942	15079
45	Fat, Ste. Etienne, France, Mahler	17.73	1.25	19.75	75	4	4.77	81.55	...	5.43	...	4	15106	14753
46	Ruhr coal, Holland, Bunte	17.46	.99	20.19	73.96	4.86	4.77	83.37	5.	00*	1.00	4.86	14220	15017
47	Ruhr coal, Shamrock, Bunte	17.19	1.10	20.44	71.53	6.93	4.79	82.36	3.	63*	1.19	6.93	14360	14882
48	Ruhr coal, Westende, Germany, Bunte	17.10	1.18	18.55	72.43	7.84	4.76	81.36	3.	33*	1.53	7.84	14233	14720
49	Ruhr coal, general, Bunte	17.02	1.42	28.04	66.92	3.62	4.81	81.96	6.	62*	1.57	3.62	14112	14836
50	Ruhr coal, Consolidaten, Germany, Bunte	16.88	1.14	23.71	70.04	5.11	4.85	81.82	6.	12*	.96	5.11	14089	14841
51	Ruhr coal, Victoria Mathias, Germany, Bunte	16.83	.98	25.28	70.46	3.28	4.80	80.72	8.	66*	1.66	3.28	13746	14650
52	Bituminous, Clover Hill, W. Va., Johnson	16.81	1.34	31.70	56.83	10.13	4.96	83.39	...	1.17	...	10.13	12625	15135
53	Ruhr coal, Zollverein, Germany, Bunte	16.79	1.64	25.03	67.03	6.30	4.75	79.77	5.	68*	1.86	6.30	13763	14482
54	Ruhr coal, Vollmond, Germany, Bunte	16.71	.92	21.52	69.75	7.81	4.77	79.76	5.	44*	1.30	7.81	13822	14472
55	Ruhr coal, Graf Moltke, Germany, Bunte	16.60	1.51	24.59	63.50	10.40	4.54	75.25	6.	72*	1.58	10.40	13025	13759
56	Saar coal, von der Heydt, Germany, Bunte	16.42	3.9	34.40	50.93	10.77	4.21	69.07	10.	93*	1.12	10.77	11660	12642
57	Ruhr coal, Dahlbusch, Germany, Bunte	16.41	2.07	24.83	56.11	16.99	4.23	69.49	6.	37*	.85	16.79	11912	12704

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TABLE LV—*Continued*

COMPOSITION AND CALORIFIC POWER OF CHARACTERISTIC COALS

No.	Name, Source, Size, Authority.	$\frac{\text{Total C}}{\text{Total H}}$	Proximate. % Moisture.	Proximate. % Volatile.	Proximate. % Fixed C.	Proximate. % Ash.	Ultimate. % H_2.	Ultimate. % C.	Ultimate. % N_2.	Ultimate. % O_2.	Ultimate. % S.	Ultimate. % Ash.	B.T.U. per Lb. By Calorimeter.	B.T.U. per Lb. By Calculation.
58	Ruhr coal, Friedrichs Ernestine, Germany, Bunte	16.33	1.54	28.38	65.12	4.96	4.94	80.59	6.	85	1.12	4.96	13925	14761
59	Saar coal, St. Ingbert, Germany, Bunte	16.32	1.73	29.81	65.63	2.83	4.99	81.49	8.	31	.65	2.83	14036	14903
60	Bituminous, Midlothian, W. Va., Johnson	16.31	.67	33.49	56.4	9.44	5.74	83.62	...	.64	...	9.44	15361	15643
61	Bit., Blue Creek, r. of m., Ala., W. B. Phillips	16.25	...	...	...	...	4.45	72.34	.89	12.25	1.06	10.16	11925	13254
62	Gas coal, Bethune, France, Mahler	16.21	1.2	28.80	65.90	4.1	5.09	82.42	...	7.19	...	4.1	14778	14983
63	Bit. r. of m., Upper Freeport Bed, Bretz, W. Va., U.S.G.S. No. 4	16.10	.98	28.72	61.87	8.43	4.85	78.21	1.5	6.11	.90	8.43	14139	14376
64	Gas coal, Lens, France, Mahler	16.04	1.05	29.55	66.40	3	5.22	83.73	...	7.01	...	3	15111	15343
65	Ruhr coal, Pluto, Germany, Bunte	16.04	1.52	...	...	2.78	5.05	80.97	9.	27*	.41	2.78	13935	14854
66	Ruhr coal, Graf Beust, Germany, Bunte	16.03	.59	24.98	71.14	3.29	5.13	82.24	10.	95*	1.68	3.29	13475	14071
67	Lignitic flaming coal, Blanzy, Ste. Marie, France, Mahler	15.98	3.9	...	...	1.9	1.97	79.38	...	9.86	...	1.9	14158	12740
68	Bit. r. of m., Upper Freeport Bed, Coalton, W. Va., U.S.G.S. No. 5	15.90	.65	20.20	59.97	10.18	4.78	76.36	1.48	6.21	.99	10.18	13828	14063
69	Ruhr coal, Recklinghausen, Germany, Bunte	15.90	1.44	27.18	66.70	4.48	5.11	81.22	6.	32*	1.43	4.48	14168	14967
70	Bit. r. of m., Kanawha Bed, Powelton, W. Va., U.S.G.S. No. 9	15.70	1.01	29.53	62.67	6.79	5.04	79.35	1.63	6.39	.80	6.79	14371	14630
71	Bit. r. of m., Upper Freeport Bed, Richard, W. Va., U.S.G.S. No. 3	15.50	1.00	30.25	58.38	10.37	4.71	76.12	1.44	6.09	1.07	10.37	13736	14091
72	Gas coal, Wigan, Lancashire, Eng., Mahler	15.48	.6	...	...	10.9	5.06	78.38	...	5.06	...	10.9	13970	14467
73	Ruhr coal, Ewald, Germany, Bunte	15.45	2.18	...	...	2.43	5.13	77.27	10.	36*	.63	2.43	13662	14664
74	Lignitic flaming coal, Montoic, France, Mahler	15.42	4.3	...	...	4.8	5.12	76.31	...	9.47	...	4.8	14022	14205
75	Ruhr coal, Mont Cenis, Germany, Bunte	15.40	2.5	25.67	53.96	17.87	4.30	66.20	7.	43*	1.70	17.87	11563	12303
76	Saar coal, Frankenholz, Germany, Bunte	15.37	1.99	37.21	54.38	6.42	5.03	77.40	7.	90*	1.26	6.42	13433	14356
77	Bit. r. of m., Thacker Coal, W. Va., Lord & Haas	15.35	1.40	35.00	51.10	6.50	5.14	78.90	1.42	6.88	1.16	6.50	13982	14637
78	Saar coal, Dodweiler, Germany, Bunte	15.31	1.32	33.19	59.72	5.77	5.11	78.26	8.	57*	.97	5.77	13508	14520

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79	Bit. r. of m., Kanawha field, Ansted, W. Va., U.S.G.S. No. 8	15.30	1.60	32.12	58.92	7.36	5.16	78.75	1.38	6.43	.92	7.36	14153	14618
80	Gas coal, Commentry, France, Mahler	15.30	3	...	...	3.4	5.25	80.18	...	8.17	...	3.4	14166	14844
81	Gas coal, Firminy, France, Mahler	15.30	1.23	...	...	3.6	5.30	81.27	...	8.59	...	3.6	14690	15033
82	Saar coal, Friedrichsthal, Germany, Bunte	15.27	2.03	37.14	54.43	6.40	4.98	76.20	9.	28*	1.11	6.40	13217	13146
83	Gas coal, Montrambert, France, Mahler	15.26	.84	...	...	3	5.33	81.27	...	9.55	...	3	14884	15051
84	Bituminous, Beaver Creek, Pa., Lord & Haas	15.25	1.5	31.33	55.42	8.75	4.89	74.6	1.40	6.90	1.96	8.75	13248	13905
85	Saar coal, Heinitz, Germany, Bunte	15.19	2.24	29.17	56.13	12.46	4.64	70.29	9.	61*	.78	12.46	12076	13064
86	Pa. bit., Clinton, Lord & Haas	15.14	2.55	35.6	53.8	8.05	4.86	73.57	1.24	7.87	1.86	8.05	13140	13730
87	Pa. bit., Carnegie, Lord & Haas	15.13	1.45	36.42	56.2	5.93	5.10	77.2	1.68	7.22	1.42	5.93	13844	14388
88	Bit. nut, Thacker coal, W. Va., Lord & Haas	15.10	1.35	36.35	56.25	6.05	5.19	78.40	1.40	7.56	1.40	6.05	14161	14606
89	Lump., bit., Hocking Valley, O., Lord & Haas	15.09	6.72	37.13	50.32	5.83	4.6	69.42	1.46	10.3	1.67	5.83	12388	12952
90	Darlington coal, Middle Kittatinny, Wampum, Pa., Lord & Haas	15.07	.75	38.53	55.77	4.95	5.17	77.93	1.65	7.95	2.35	4.95	14085	14574
91	Hocking Valley, r. of m., Ohio, Lord & Haas	15.04	6.65	34.14	49.54	9.67	4.42	66.5	1.43	10.66	1.67	9.67	11693	12419
92	Saar coal, Püttlingen, Germany, Bunte	15.02	3.93	31.12	53.72	11.23	4.57	68.67	10.	80*	.80	11.23	11759	12770
93	Pa. bit., Turtle Creek, Lord & Haas	15.00	1.08	34.38	56.59	7.95	5.10	76.56	1.67	6.04	1.6	7.95	13734	14292
94	Bit., Pittsburgh coal, Carnegie, Pa., Lord & Haas	14.93	1.07	37.79	55.06	6.08	5.13	76.57	1.64	8.82	1.76	6.08	13977	14317
95	Bit., Wakeford, Ohio, Lord & Haas	14.93	1.55	37.29	53.34	7.82	4.98	74.39	1.4	6.42	3.44	7.82	13426	13982
96	Saar coal, Itzenpletz, Germany, Bunte	14.92	3.61	32.67	59.02	4.70	4.85	75.11	10.	68*	1.05	4.70	13906	13806
97	Darlington coal, Middle Kitatinny, Hoytdale, Pa., Lord & Haas	14.91	1.60	36.40	57.65	4.35	5.22	77.83	1.65	9.38	1.57	4.35	14013	14548
98	Indiana, bit., Noyes, McTaggart & Craven	14.80	8.98	34.49	50.3	6.28	4.76	70.5	1.36	16.29	1.39	6.28	13084	13095
99	Same as 97	14.76	2.70	35.10	53.50	8.70	4.93	73.78	1.34	10.57	1.68	8.70	13041	13580
100	Bit. Pittsburgh coal, Turtle Creek, Pa., Lord & Haas	14.75	1.75	36.20	53.00	9.05	5.05	74.48	1.37	8.39	1.66	9.05	13309	13941
101	Darlington coal, Middle Kitatinny, Beaver Creek, Pa., Lord & Haas	14.74	1.50	34.33	55.42	8.75	5.06	74.60	1.40	8.23	1.96	8.75	13248	13998
102	Saar coal, König, Germany, Bunte	14.74	1.21	37.72	54.32	6.75	5.20	76.69	8.	05*	2.10	6.75	13628	14391
103	Bit. Pittsburgh coal, Carnegie, Pa., Lord & Haas	14.70	1.45	36.42	56.20	5.93	5.26	77.20	1.68	8.51	1.42	5.93	13844	14473
104	Bit. r. of m., Pittsburgh Bed, Kingmont, W. Va., U.S.G.S. No. 1	14.70	1.35	36.92	55.36	6.37	5.26	78.31	1.55	7.61	.90	6.37	14164	14645
105	Darlington coal, Middle Kitatinny, Wampum, Pa., Lord & Haas	14.70	.70	36.80	55.85	6.65	5.22	76.81	1.62	8.52	1.18	6.65	13748	14413
106	Upper Freeport coal, Yellow Creek, O., Lord & Haas	14.69	1.23	38.72	50.88	9.17	4.98	73.15	1.40	7.41	3.89	9.17	13615	13845
107	Bit. Pittsburgh coal, Turtle Creek, Pa., Lord & Haas	14.67	1.08	34.48	56.59	7.95	5.22	76.56	1.67	7.00	1.60	7.95	13734	14364
108	Lignitic flaming coal, Decazeville, Bourran, France, Mahler	14.64	3.5	...	...	4.85	5.17	74.73	...	11.76	...	4.85	13344	14013

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TABLE LV—*Continued*

COMPOSITION AND CALORIFIC POWER OF CHARACTERISTIC COALS

No.	Name, Source, Size, Authority.	Total C / Total H	Proximate.				Ultimate.						B.T.U. per Lb.	
			% Moisture.	% Volatile.	% Fixed C.	% Ash.	% H_2.	% C.	% N_2.	% O_2.	% S.	% Ash.	By Calorimeter.	By Calculation.
109	Saar coal, Kohlwald, Germany, Bunte	14.61	4.05	35.74	54.56	5.65	5.03	73.48	10.	86	.93	5.65	12580	13773
110	Bit. r. of m., Straight Creek, East Field, Kent, U.S.G.S. No. 1	14.60	1.92	36.56	57.08	4.44	5.36	78.31	1.85	8.80	1.24	4.44	14319	14690
111	Bit. r. of m., Wheatcroft, Western Field, Ken., U.S.G.S. No. 4	14.60	2.54	36.08	46.79	14.59	4.53	66.5	1.28	8.43	4.67	14.59	12294	12804
112	Upper Freeport coal, Palestine, Ohio, Lord & Haas	14.55	2.45	36.60	52.70	8.25	5.06	73.64	1.24	9.47	2.34	8.25	13212	13712
113	Bit., lump and nut, Warrior Field, Horse Creek, Ala., U.S.G.S. No. 1	14.50	1.55	33.10	53.71	12.64	4.96	72.16	1.66	7.85	.73	12.64	12958	13572
114	Bit. lump and nut, Warrior Field, Carbon Hill, Ala., U.S.G.S. No. 2	14.50	2.58	33.15	51.74	12.53	4.79	69.24	1.55	10.87	1.02	12.53	12449	13025
115	Bit., lump and nut, Pittsburgh Bed, West Mineral, Kan., U.S.G.S. No. 5	14.50	1.84	37.40	54.97	10.79	4.96	71.90	1.09	7.40	3.86	10.79	13199	13629
116	Upper Freeport coal, East Palestine, Ohio, Lord & Haas	14.46	.82	34.98	52.65	11.89	4.88	70.58	1.24	7.70	3.65	11.89	12796	13381
117	Upper Freeport coal, Waterford, Ohio, Lord & Haas	14.45	1.55	37.29	53.34	7.82	5.15	74.39	1.40	7.80	3.44	7.82	13426	14108
118	Lignitic flaming coal, Blanzy, Ste. Eugenie, France, Mahler	14.45	1.7	...	...	7.8	5.14	75.27	...	10.08	...	7.8	13474	14063
119	Pa. bit., Creedmoor, Lord & Haas	14.45	1.09	38.91	51.14	8.86	5.15	74.45	1.60	7.05	1.80	8.86	13493	14032
120	Saar coal, Reden, Germany, Bunte	14.43	3.45	34.25	56.08	6.62	5.06	72.98	11.	30*	.99	6.62	12548	13722
121	Bit. r. of m., Weir-Pittsburgh Bed, Clarksburg, W. Va., U.S.G.S. No. 2	14.40	1.46	40.14	50.50	7.90	5.09	74.44	1.37	7.70	3.50	7.70	13860	14053
122	Mahoney coal, Salemville, Ohio, Lord & Haas	14.37	3.15	35.00	50.95	10.90	4.95	71.13	1.23	9.93	1.86	10.90	12722	13419
123	Ohio bit., Cambridge, Lord & Haas	14.35	2.43	37.79	50.36	9.42	4.92	70.61	1.44	8.17	3.01	9.42	12758	13372
124	Darlington coal, Middle Kitatinny, Clinton, Pa., Lord & Haas	14.31	2.55	35.50	53.80	8.05	5.14	73.57	1.24	10.14	1.86	8.05	13140	13901
125	Bit., Hartshorne, Hartshorne, Ind. Terr., U.S.G.S., No. 2	14.30	1.70	37.19	49.79	11.32	5.00	71.49	1.72	8.91	1.56	11.32	12969	12511

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126	Upper Freeport coal, Palestine Ohio, Lord & Haas.	14.26	2.15	36.70	50.70	10.45	5.00	71.29	1.34	9.28	2.64	10.45	13845	12524
127	Same	14.22	1.65	37.45	51.32	9.58	5.15	73.23	1.47	8.82	1.75	9.58	13194	13853
128	Upper Freeport coal, Steubenville, O., Lord & Haas.	14.21	1.47	39.23	51.54	7.66	5.26	74.73	1.44	8.06	2.85	7.66	13507	14181
129	Pittsburgh coal, Carnegie, Pa., Lord & Haas	14.16	1.08	37.67	52.00	9.25	5.19	73.50	1.44	8.08	2.54	9.25	13313	13966
130	Pittsburgh coal, North Mansfield, Pa., Lord & Haas	14.16	2.10	36.20	52.65	9.05	5.15	73.91	1.23	8.89	1.77	9.05	13237	13962
131	Upper Freeport coal, Salemville, Ohio, Lord & Haas	14.15	2.80	36.30	52.80	8.10	5.13	72.62	1.23	9.92	3.00	8.10	13097	13793
132	Same, New Galilee, Ohio, Lord & Haas	14.15	2.30	36.70	52.30	8.70	5.20	73.57	1.35	8.94	2.24	8.30	13322	13943
133	Pittsburgh coal, Creedmore, Pa., Lord & Haas	14.11	1.09	38.91	51.14	8.86	5.27	74.45	1.60	8.02	1.80	8.86	13493	14115
134	Bit. r. of m., McAlester Bed, Edwards, Ind. Ter., U.S.G.S. No. 3	14.10	3.45	37.45	47.82	11.28	4.85	68.18	1.50	10.57	3.63	11.28	12469	13004
135	Saxon brown coal, Bachbei, Ziebingen, Ger., Bunte.	14.03	45.33	28.33	24.45	1.99	2.56	35.93	13.	20*	.99	1.99	5339	6318
136	Bit., lump and nut and slack, Weir-Pittsburgh Bed, Yale, Kan., U.S.G.S. No. 2	13.90	2.23	31.87	47.63	18.27	4.56	63.14	.94	6.69	6.40	18.27	11880	12203
137	Lignitic flaming coal, Decazeville, Tramont, France, Mahler	13.89	1.58	...	...	2.8	5.43	75.27	...	14.92	...	2.8	13489	14240
138	Darlington coal, Middle Kitaninny, Wampum, Pa., Lord & Haas	13.85	2.85	37.50	50.85	8.80	5.25	72.82	1.33	8.55	3.25	8.80	13147	13903
139	Ala. bit., Mary Lee (top), W. B. Phillips	13.77	...	...	...	...	5.54	76.18	.55	8.93	1.15	8.9	13223	14484
140	Bit. r. of m., Marion, Ill., U.S.G.S., No. 3	13.70	5.96	30.29	52.16	11.59	4.92	67.30	1.43	12.99	1.77	11.59	12103	12850
141	Lignite, Trifail, Styria, Mahler	13.68	.71	...	...	4.75	4.78	65.45	...	24.30	...	4.75	11311	12427
142	Upper Freeport coal, Cambridge, O., Lord & Haas.	13.61	2.43	37.79	50.36	9.42	5.19	70.61	1.44	10.33	3.01	9.42	12758	13545
143	Lump and slack, Henryetta Bed, Ind. Ter., U.S.G.S. No. 1	13.60	3.87	35.73	50.05	10.35	5.14	69.85	1.29	11.38	1.99	10.35	12620	13355
144	Cannel gas coal, Middrie, France, Mahler	13.51	3.95	...	...	4.7	6	76.55	...	8.8	...	4.7	13865	14781
145	Lump and fine, Laddsville, Wapello Co., Iowa, U.S.G.S. No. 1	13.40	5.21	31.76	46.51	16.52	4.61	61.80	.97	10.90	5.20	16.52	11392	12012
146	Saxon brown coal, Greppen, Germany, Bunte	13.33	22.85	38.64	27.45	11.06	3.25	43.77	17.	54*	1.93	11.06	6966	8355
147	Jackson Co., Ohio, West, Lord & Haas	13.30	8.65	34.30	55.40	11.65	5.37	71.42	1.43	19.49	.64	11.65	12231	13669
148	Lignite, Vaurigard, France, Mahler	13.24	3.14	...	...	6.75	4.51	59.80	25.	8*	...	6.75	9965	11433
149	Mix. bit., Osage River, Johnson	13.20	1.67	41.83	51.16	5.34	6.20	81.85	...	1.98	...	5.34	13744	15663
150	Upper Bavarian coal, Haushmner, Grobkohle, Germany, Bunte	13.13	7.37	36.13	43.19	13.31	4.42	58.01	12.	02*	4.87	13.31	10121	11331
151	Lump, McAlester Bed, Lehigh, Ind. Ter., U.S.G.S. No. 4	13.10	4.91	37.79	43.90	13.40	4.84	63.21	1.38	13.15	4.02	13.40	11389	12287
152	Hocking Valley coal, lump, Middle Kitatinny, Ohio, Lord & Haas	12.98	6.72	37.13	50.32	5.83	5.35	69.42	1.46	16.27	1.67	15.83	12220	12953
153	Jackson Co., Ohio, North, Lord & Haas	12.95	8.45	34.09	54.09	3.38	5.50	71.20	1.45	17.71	.76	3.38	12402	13729

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TABLE LV —*Concluded*

COMPOSITION AND CALORIFIC POWER OF CHARACTERISTIC COALS

No.	Name, Source, Size, Authority.	Total C / Total H	Proximate.				Ultimate.						B.T.U. pr Lb.	
			% Moisture.	% Volatile.	% Fixed C.	% Ash.	% H_2.	% C.	% N_2.	% O_2.	% S.	% Ash.	By Calorimeter.	By Calculation.
154	Lump, Atchison Field, Atchison, Kan., U.S.G.S. No. 4	12.90	3.57	37.00	46.80	12.63	5.04	65.02	1.07	7.91	8.33	12.63	12337	12845
155	Jackson Co., Ohio, Center, Lord & Haas	12.90	8.26	35.15	53.49	4.10	5.43	70.05	1.49	17.09	1.84	4.10	12303	13553
156	R. of m., Rich Hill Field, Sprague, Mo., U.S.G.S. No. 1	12.90	3.50	35.35	40.77	20.38	4.64	60.00	.99	8.64	5.53	20.38	11144	11760
157	Hocking Valley coal, r. of m., Middle Kitaninny, Ohio, Lord and Haas	12.88	6.65	34.14	49.54	9.67	5.16	66.50	1.43	15.57	1.67	9.67	11736	12868
158	Indiana bit., Lancaster, Noyes, McTaggart & C.	12.84	12.66	37.44	47.22	2.68	5.56	71.41	1.54	18.42	.62	2.68	10645	13783
159	Jackson Co., Ohio, South, Lord & Haas	12.77	7.02	37.66	50.82	4.48	5.49	70.12	1.50	16.96	1.45	4.48	12348	13684
160	Same, Eastern District, Lord & Haas	12.75	8.50	37.75	57.10	2.65	5.55	70.79	1.46	18.60	1.95	2.65	12337	14035
161	Hocking Valley coal, lump, Middle Kitaninny, Ohio, Lord & Haas	12.72	6.40	36.05	49.05	8.50	5.36	68.18	1.44	15.09	1.43	8.50	12132	13224
162	Lump and nut, Earlington, Ky., Western Field, U.S.G.S. No. 2	12.70	5.36	38.99	46.27	9.38	5.33	67.64	1.25	12.68	3.72	9.38	12312	13219
163	Indiana bit., New Pittsburgh, Noyes, McTaggart & Craven	12.62	6.83	39.92	39.93	13.3	5.07	62.88	1.01	13.06	7.46	13.3	11134	12518
164	R. of m., Earlington, Ky., U.S.G.S. No. 3	12.60	5.85	36.90	46.96	10.29	5.27	66.75	1.43	12.66	3.60	10.27	12292	12048
165	R. of m., Barnett, Morgan Co., Mo., U.S.G.S. No. 4	12.60	5.39	44.91	44.47	5.23	5.77	72.45	.75	10.25	5.55	5.23	13528	14258
166	Saxon brown coal, Alfred, Germany, Bunte	12.58	36.26	33.39	23.27	7.08	3.29	41.41	9.	84	3.12	7.08	6734	8143
167	Upper Bavarian coal, Pernsberger, Fördeköhle, Germany, Bunte	12.48	10.18	34.69	33.08	22.05	3.83	47.78	10.	92	5.24	22.05	8478	10379
168	R. of m., Hamilton, Marion Co., Iowa, U.S.G.S. No. 2	12.40	4.25	37.02	41.47	16.99	4.84	60.36	1.46	11.65	5.20	16.99	11182	11538
169	R. of m., Coffeen, Montgomery Co., Ill., U.S.G.S. No. 6	12.30	5.13	32.68	47.46	14.73	4.88	60.51	1.23	14.20	4.45	14.73	11158	11921
170	R. of m., Booneville, Warwick Co., Ind., U.S.G.S. No. 2	12.30	6.24	37.49	42.76	13.51	5.11	62.97	1.25	12.56	4.60	13.51	11538	12442

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171	Lump, Altoona, Polk Co., Iowa, U.S.G.S. No. 3....	12.30	4.52	40.96	38.99	15.53	4.93	60.62	.93	11.16	6.83	15.53	11356	12079
172	Lump and nut, Belleville Field, O'Fallen, Ill., U.S.G.S. No. 1..........	12.20	6.28	38.92	41.06	13.72	5.09	62.01	1.07	13.86	4.25	13.72	11144	12295
173	R. of m., Cambria Field, Cambria, Wyo., U.S.G.S. No. 2..........	12.20	2.73	37.61	37.40	22.26	4.54	55.29	.80	12.94	4.17	22.26	10364	10962
174	Saxon brown coal, Marie Louise, Germany, Bunte. .	12.17	29.27	35.83	27.61	7.29	3.73	45.40	10.	72	3.59	7.29	7742	9007
175	Saxon brown coal, Menzelwitz, Fortschritt, Germany, Bunte..........	12.10	27.13	37.28	27.27	8.32	3.67	44.47	14.	69	1.72	8.32	7306	6763
176	R. of m., Mildred, Sull. Co., Ind., U.S.G.S. No. 1..	11.90	8.66	34.86	42.67	13.81	5.20	62.20	1.22	14.99	2.58	13.81	11405	12302
177	Lump, Belleville Field, Troy, Ill., U.S.G.S. No. 4. ..	11.60	11.40	32.45	44.30	11.85	5.33	61.79	1.17	18.52	1.34	11.85	10911	12271
178	Lignite, Terre de Feu, France, Mahler..........	11.59	16.5	...	...	18.5	3.86	46.16	...	14.98	...	18.5	8795	9054
179	Lump, Centerville, Appanoose Co., Iowa, U.S.G.S. No. 4..........	11.50	10.03	37.27	41.22	11.48	5.31	61.25	.94	16.56	4.46	11.48	11227	12304
180	Black lignite and washed nut, Red Lodge, Mont., U.S.G.S. No. 1..........	11.50	9.05	36.70	43.03	11.22	5.25	60.41	1.36	20.00	1.76	11.22	10777	12039
181	Lignite, Josefsziche in Schwanenkirchen, Ger., Bunte	11.34	40.35	26.65	18.11	15.89	2.54	28.80	9.	55	2.87	15.89	4640	5843
182	R. of m., Bevier Field, Mo., U.S.G.S. No. 2........	11.30	9.14	34.53	39.02	17.31	4.96	56.25	.99	15.19	5.30	17.31	10451	12400
183	R. of m., Charlton, Lucas Co., Ia., U.S.G.S. No. 5.	11.20	9.22	32.71	44.52	13.55	5.35	59.89	1.22	16.57	3.42	13.55	10989	13191
184	Black lignite, lump and slack, Gallop Field, New Mexico, U.S.G.S. No. 1..........	11.20	10.86	35.14	46.90	7.10	5.73	64.34	1.05	21.14	6.64	7.10	11435	13097
185	Same, slack, U.S.G.S. No. 2..........	11.20	8.13	34.82	37.63	19.22	5.65	56.71	.98	16.74	1.30	19.22	10202	11725
186	Lignite, Pressdorf von Hofmark Steinfels, Germany, Bunte..........	11.00	16.47	52.28	25.97	5.28	4.48	49.31	24.	07	.39	5.28	7855	9903
187	Brown lignite, Hoyt, Wood Co., Tex., U.S.G.S. No. 2	10.90	10.66	39.42	40.11	9.81	5.28	57.31	1.06	25.83	.71	9.81	9904	11563
188	Black lignite, Boulder Field, Lafayette, Colo., U.S.G.S. No. 1..........	10.60	13.49	37.11	43.03	6.37	5.75	61.13	1.22	24.95	.58	6.37	10791	11401
189	Peat of Pschorrschwige, Germany, Bunte..........	10.59	29.14	41.26	22.69	6.91	3.66	38.76	21.	27	.26	6.91	5909	7867
190	Brown lignite, Lehigh Field, N. Dak., U.S.G.S. No. 1	10.1	15.42	38.73	33.61	12.24	5.22	52.66	.71	27.15	2.02	12.24	9061	10904
191	Brown lignite, Williston Field, N. Dak., U.S.G.S. No. 2..........	9.8	16.70	37.10	39.49	6.71	5.61	55.16	.91	30.98	.63	6.71	9491	11449
192	Peat of Ostrach, Germany, Bunte..........	9.78	11.06	52.78	27.64	5.52	4.70	45.93	29.	18	.61	5.52	7187	9553
193	Black lignite, Sheridan Field, Wyo., U.S.G.S. No. 1.	9.6	17.69	37.96	39.56	4.79	6.09	58.41	1.09	29.99	.63	4.79	10355	12212
194	Brown lignite, Houston Co., Tex., U.S.G.S. No. 1 ..	9.4	13.40	42.75	29.00	14.85	5.51	52.06	.95	25.33	1.04	14.85	9358	10991
195	Cannel coal, Albertite, Nova Scotia, Kent..........	9.04	...	...	...	...	9.14	82.67	8.	19	...	...	....	17564
196	Cannel coal, Tasmanite, Tasmania, Kent..........	7.62	...	...	...	...	10.41	79.34	4.	93	5.32	...	....	17872

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TABLE LVI

COMBUSTIBLE AND VOLATILE OF COALS, LIGNITES, AND PEAT

No.	Name, Source, Size, Authority.	Combustible = Coal Less (Moisture + Ash). Ratio of Total $\frac{C.}{H.}$	Proximate. Volatile, %	Proximate. Fixed C, %	Ultimate. H_2 %	Ultimate. C %	Ultimate. O_2, N_2, S %	B.T.U. per Pound. Total	B.T.U. per Pound. From Fixed C.	B.T.U. per Pound. From Volatile.	B.T.U. Lb. Vol. = B.T.U. Lb. Comb., Less C in Comb. × 14544 divided by Vol. in Comb.	Ratio of $\frac{\text{Fixed C.}}{\text{Vol.}}$
1	Anth. de la Mure, Grande Couche, France, Mahler	63.5	2.75	97.25	1.50	95.24	3.26	14789	14144	645	23455	35.36
2	Anthracite, Treverton, Penn., U. S. A., Isherwood	52.31	7.23	92.77	1.87	98.18	.91	15190	13492	1698	23480	12.82
3	Anthracite, Pennsylvania, U. S. A., Mahler	43.35	3.00	97.00	2.20	95.37	2.43	14816	14107	709	23600	32.33
4	Anthracite, Hoy Daong (Tonkin), France, Mahler	43.00	3.17	96.83	2.16	92.86	4.99	14618	14083	535	16877	30.54
5	Bit., Pa., Ormsby, U. S. A., Isherwood	35.50	42.20	57.8	2.66	94.50	2.84	14971	8406	6565	15557	1.37
6	Anthracite, Keban, France, Mahler	30.44	5.20	94.80	3.07	93.40	5.39	15357	13788	1569	30173	18.23
7	Anthracite, Commentry, France, Mahler	29.32	3.19	96.81	3.12	91.49	5.39	15221	14080	1141	35768	30.34
8	Anth., Blanzy, Ste. Barbe, France, Mahler	28.40	6.00	94.00	3.17	90.60	6.83	14725	13671	1054	17567	15.66
9	Anthracite culm, Scranton, U.S.G.S. No. 3	26.7	8.91	91.09	3.37	89.88	6.75	15256	13248	2008	22536	10.22
10	Anthracite Creusot, France, Mahler	24.41	10.44	89.56	3.78	92.93	3.83	15635	13026	2609	24990	8.57
11	Anth., Grande Combe Purts Petassus, Fr., Mahler	23.15	6.71	93.29	3.95	91.46	4.59	15372	13568	1804	26885	13.90
12	Ruhr coal, Hörde, Germany, Bunte	21.75	14.6	85.4	4.12	89.62	6.26	15072	12421	2651	18157	5.74
13	Ruhr coal, Bickefeld, Germany, Bunte	21.68	13.9	86.1	4.24	89.93	5.83	15269	12522	2747	19763	6.19
14	Semi-fat d'Anzin, Fosse St. Marc, France, Mahler	21.37	14.08	85.92	4.27	91.26	4.48	15401	12496	2905	20632	6.10
15	Semi-anth., Spadra Bed, Coalhill, Ark., U.S.G.S. No. 5	20.7	14.82	85.18	4.26	88.04	7.70	15497	12388	3109	20978	5.75
16	Semi-fat Roche-la-Moliere, France, Mahler	20.57	14.00	86.00	4.38	90.11	5.51	15781	12508	3273	23378	6.14
17	Semi-fat, Auiche, France, Mahler	20.48	11.93	88.07	4.40	90.10	5.49	15901	12809	3092	25918	7.38
18	Semi-fat, Grande Combe, France, Mahler	20.45	13.38	86.62	4.46	91.19	4.35	15761	12598	3163	23639	6.47
19	Ruhr coal, Fröbliche Morgensonne, Ger., Bunte	20.27	14.5	85.5	4.51	91.40	4.09	15556	12435	3121	21524	5.89
20	Semi-bit., Pocahontas, W. Va., Lord & Haas	20.27	19.9	80.1	4.50	91.00	4.50	15782	11650	4132	20763	4.03
21	Semi-bit., r. of m., Pocahontas, Va., Lord & Haas	20.11	19.86	80.14	4.94	90.56	4.50	15717	11655	4062	20413	4.04
22	Same	19.84	19.9	80.10	4.55	90.3	5.15	15782	11650	4132	20763	4.03
23	Same bed, Zenith, W. Va., U.S.G.S. No. 11	19.60	19.27	80.73	4.55	89.4	6.05	15923	11741	4182	21702	4.19
24	Bit., r. of m., Windber, Pa., U.S.G.S. No. 1	19.50	17.27	82.73	4.54	88.54	6.92	15847	12032	3815	22090	4.79
25	Run of mine, Pocahontas, Virginia, Lord & Haas	19.45	19.71	80.29	4.61	89.71	5.68	15799	11674	4122	20913	4.07

26	Ruhr coal, Dannenbaum, Germany, Bunte	19.32	22.2	77.80	4.62	89.65	5.73	15309	11315	3994	17991	3.50
27	Bit., lump, Huntington Bed, Bonanza, Ark., U.S.G.S No. 2	19.30	18.08	81.92	4.55	88.28	7.17	15520	11914	3606	19945	4.53
28	Semi-bit., r. of m., Pocahontas, Field, Big Sandy, W. Va., U.S.G.S. No. 12	19.20	19.53	80.47	4.68	89.88	5.44	15930	11704	4226	21638	4.12
29	Fat, Anzin, France, Mahler	19.10	21.51	78.49	4.67	89.20	6.14	15433	11416	4017	18675	3.65
30	Bit., lump and nut, Huntington Bed, Ark., U.S.G.S. No. 1	18.90	20.33	79.67	4.59	86.87	8.54	15684	11587	4097	20152	3.92
31	Bit., lump and slack, Huntington Bed, Jenny Lind, Ark., U.S.G.S. No. 3	18.80	22.60	77.40	4.61	86.59	8.80	14010	11257	2753	12181	3.42
32	Semi-bit., r. of m., New River Bed, Sun, W. Va., U.S.G.S. No. 7	18.80	21.81	78.19	4.61	86.83	8.56	15780	11372	4408	20211	3.58
33	Ruhr coal, Bonifacius, Germany, Bunte	18.78	18.00	82.00	4.59	86.23	8.57	14697	11926	2771	15394	4.55
34	Fat, Lens, France, Mahler	18.75	19.50	80.50	4.80	90.03	5.17	15910	11707	4203	21554	4.13
35	Semi-bit., r. of m., Pocahontas Field, Mora, W. Va., U.S.G.S. No. 10	18.70	19.85	80.15	4.80	90.08	5.12	16030	11657	4373	22030	4.04
36	Fat, Roche-la-Moliere, France, Mahler	18.49	22.85	77.15	4.84	89.53	5.63	15961	11221	4740	20744	3.38
37	Fat, Rouchamp, France, Mahler	18.36	23.23	76.77	4.84	88.89	6.27	15835	11165	4670	20103	3.30
38	Bituminous, Cumberland, Md., U. S. A., Isherwood	18.21	13.86	86.14	5.08	92.36	2.56	16320	12528	3792	27359	6.22
39	Ruhr coal, Oberhausen, Germany, Bunte	18.20	19.40	80.6	4.88	88.82	6.30	15161	11722	3439	17727	4.15
40	Ruhr coal, Mathias Stinnes, Germany, Bunte	18.17	21.8	78.2	4.90	89.05	6.05	16865	11374	5491	25193	5.58
41	Ruhr coal, Lothringen, Germany, Bunte	18.15	23.5	76.5	4.82	87.52	7.66	14944	11126	3818	16247	3.26
42	Fat, Carmaux, France, Mahler	18.04	21.75	78.25	4.87	87.84	7.30	15550	11381	4169	19168	3.60
43	Fat, Mines-des-Ports (Gard), France, Mahler	17.92	19.29	80.71	4.84	86.52	8.64	15601	11738	3863	20080	4.19
44	Semi-bit., r. of m., New River Field, Rush Run, W. Va., U.S.G.S. No. 6	17.80	23.06	76.94	4.95	88.11	6.94	15850	11190	4660	20208	3.34
45	Fat, Ste. Etienne, France, Mahler	17.73	20.84	79.16	5.03	89.23	5.47	15943	11513	4430	21257	3.80
46	Ruhr coal, Holland, Germany, Bunte	17.46	21.40	78.60	5.07	88.53	6.38	15103	11432	3671	17154	3.67
47	Ruhr coal, Shamrock, Germany, Bunte	17.19	22.20	77.80	5.21	89.55	5.24	15613	11315	4298	19360	3.50
48	Ruhr coal, Westende, Germany, Bunte	17.10	20.4	79.6	5.23	89.43	4.74	16179	11576	4603	22559	3.90
49	Ruhr coal, general, Germany, Bunte	17.02	29.5	70.5	5.07	86.31	8.62	14861	10254	4607	15620	2.39
50	Ruhr coal, Consolidaten, Germany, Bunte	16.88	25.3	74.7	5.17	87.27	6.53	15028	10864	4164	16458	2.95
51	Ruhr coal, Victoria Mathias, Germany, Bunte	16.83	26.4	73.6	5.01	84.31	10.68	14357	10704	3653	13837	2.79
52	Bituminous, Clover Hill, W. Va., U. S. A., Johnson	16.81	35.81	64.19	5.65	84.20	13.57	14423	9336	5087	14205	1.79
53	Ruhr coal, Zollverein, Germany, Bunte	16.79	27.2	72.8	5.16	86.65	8.19	14950	10588	4362	16037	2.68
54	Ruhr coal, Vollmond, Germany, Bunte	16.71	23.6	76.4	5.23	87.39	7.38	15311	11111	4200	17792	3.24
55	Ruhr coal, Graf Moltke, Germany, Bunte	16.60	27.1	72.9	5.15	85.43	9.42	14786	10603	4183	15435	2.69

Table LVI—*Continued*

COMBUSTIBLE AND VOLATILES OF COALS, LIGNITES, AND PEATS

No.	Name, Source, Size, Authority.	Combustible = Coal Less (Moisture + Ash.) Ratio of Total. $\frac{C.}{H.}$	Proximate. Volatile, %	Proximate. Fixed C, %	Ultimate. H_2 %	Ultimate. C %	Ultimate. O_2, N_2, S. %	B.T.U. per Pound. Total	B.T.U. per Pound. From Fixed C.	B.T.U. per Pound. From Volatile.	B.T.U. Lb. Vol. = B.T.U. Lb. Comb. Less C in Comb. × 14544 divided by Vol. in Comb.	Ratio of $\frac{\text{Fixed C.}}{\text{Vol.}}$
56	Saar coal, von der Heydt, Germany, Bunte	16.42	40.3	59.7	4.93	80.95	14.12	13664	8683	4981	12360	1.49
57	Ruhr coal, Dahlbusch, Germany, Bunte	16.41	30.7	69.3	5.23	85.85	8.92	14717	10079	4638	15107	2.26
58	Ruhr coal, Friedrich Ernestine, Germany, Bunte	16.33	30.5	69.5	5.28	86.19	8.53	14893	10108	4785	15688	2.28
59	Saar coal, St. Ingbert, Germany, Bunte	16.32	31.2	68.8	5.23	85.38	9.39	14707	10006	4701	15067	2.21
60	Bit., Midlothian, W. Va., U. S. A., Johnson	16.31	37.25	62.75	6.30	93.02	0.72	17088	9126	7962	21374	1.68
61	Bit., r. of m., Blue Creek, Ala., U. S. A., Phillips	16.25	....	....	4.95	80.52	14.53					
62	Gas coal, Bethune, France, Mahler	16.21	30.41	69.59	5.37	87.03	7.60	15602	10121	5481	18024	2.29
63	Bit., r. of m., Upper Freeport Bed, Bretz, W. Va., U.S.G.S. No. 4	16.10	31.70	68.30	5.29	85.42	9.29	15607	9934	5673	17893	2.15
64	Gas coal, Lens, France, Mahler	16.04	30.80	69.20	5.44	87.26	7.30	15748	10064	5684	18451	2.25
65	Ruhr coal, Pluto, Germany, Bunte	16.04	....	....	5.28	84.60	10.12					
66	Ruhr coal, Graf Beust, Germany, Bunte	16.03	26.0	74.0	5.13	82.24	12.63	14018	10762	3256	12519	2.84
67	Lignitic flaming coal, Blanzy Purts, Ste. Marie, France, Mahler	15.98	31.35	68.65	5.27	84.26	10.46	15031	9984	5047	16099	2.19
68	Bit., r. of m., Upper Freeport Bed, Coalton, W. Va., U.S.G.S. No. 5	15.90	32.75	67.25	5.32	85.02	9.66	15514	9780	5734	17505	2.05
69	Ruhr coal, Recklinghausen, Germany, Bunte	15.90	28.9	71.1	5.43	86.33	8.24	15075	10341	4734	16380	2.46
70	Bit., r. of m., Kanawha Bed, Powelton, W. Va., U.S.G.S. No. 9	15.70	32.03	67.97	5.41	85.13	9.46	15586	9886	5700	17793	2.12
71	Bit., r. of m., Upper Freeport Bed, Richard, W. Va., U.S.G.S. No. 3	15.50	34.13	65.87	5.47	84.93	9.60	15498	9580	5918	17336	1.93
72	Gas coal, Wigan, Lancashire, Eng., Mahler	15.48	31.64	68.36	5.72	88.57	5.72	15782	9942	5840	18454	2.16
73	Ruhr coal, Ewald, Germany, Bunte	15.45	....	....	5.38	83.10	11.52					
74	Lignitic flaming coal, Montoic, France, Mahler	15.42	37.07	62.93	5.64	86.95	10.42	15426	9153	6273	16919	1.70
75	Ruhr coal, Mont Cenis, Germany, Bunte	15.40	32.2	67.8	5.40	83.14	11.46	14521	9861	4660	14470	2.10
76	Saar coal, Frankenholz, Germany, Bunte	15.37	40.6	59.4	5.50	84.51	9.99	14666	8639	6027	14842	1.46
77	Bit., r. of m., Thacker coal, W. Va., Lord & Haas	15.35	38.0	62.00	5.49	84.39	10.12	15161	9017	6144	16168	1.63

78	Saar coal, Dudweiler, Germany, Bunte	15.31	35.7	64.3	5.50	84.23	10.27	14603	9352	5251	14709	1.80
79	Bit., r. of m., Kanawha Bed, Ansted, W. Va., U.S.G.S. No. 8	15.30	35.28	64.72	5.57	85.01	9.42	15545	9413	6132	17381	1.83
80	Gas coal, Commentry, France, Mahler	15.30	39.96	60.04	5.60	85.66	8.73	15134	8732	6402	16021	1.50
81	Gas coal, Firminy, France, Mahler	15.30	32.02	67.98	5.58	85.39	91.13	15431	9887	5544	17314	2.12
82	Saar coal, Friedrichsthal, Germany, Bunte	15.27	40.6	59.4	5.45	82.21	11.34	14438	8638	5800	14283	1.46
83	Gas coal, Montrambert, France, Mahler	15.26	34.27	65.73	5.54	84.52	9.94	15440	9560	5880	17158	1.92
84	Bit., Beaver Creek, Pa., U. S. A., Lord & Haas	15.25	38.25	61.75	5.45	85.12	9.43	14761	8981	5780	15111	1.61
85	Saar coal, Heinitz, Germany, Bunte	15.14	34.20	65.80	5.44	82.38	12.18	14157	9570	4587	13410	1.92
86	Bit., Clinton, Pa., U. S. A., Lord & Haas	15.14	39.83	60.18	5.44	82.29	12.27	14697	8752	5945	14923	1.51
87	Bit., Carnegie, Pa., U. S. A., Lord & Haas	15.13	39.32	60.68	5.51	83.35	11.14	14947	8824	6123	15569	1.54
88	Bit., nut, Thacker coal, W. Va., Lord & Haas	15.10	39.25	60.75	5.52	83.45	11.03	15293	8834	6459	16453	1.55
89	Bit., lump, Hocking Valley, Ohio, Lord & Haas	15.09	42.46	57.54	5.26	79.38	15.36	14165	8369	5796	13650	1.36
90	Darlington coal, Middle Kitaninny, Wampum, Pa., Lord & Haas	15.07	40.86	59.14	5.44	81.99	12.57	14861	8601	6260	15320	1.45
91	Bit., r. of m., Hocking Valley, Ohio, Lord & Haas	15.04	40.80	59.20	5.28	79.47	16.25	13973	8610	5363	13140	1.45
92	Saar coal, Püttlingen, Germany, Bunte	15.02	36.7	63.3	5.39	80.94	13.67	13860	9206	4654	12681	1.72
93	Bit., Turtle Creek, Pa., U. S. A., Lord & Haas	15.00	37.79	62.21	5.61	84.16	10.23	15097	9048	6049	16007	1.65
94	Bit., Pittsburgh coal, Carnegie, Pa., Lord & Haas	14.93	40.70	59.30	5.46	81.53	13.01	15034	8625	6409	15747	1.46
95	Bit., Waterford, Ohio, U. S. A., Lord & Haas	14.93	41.15	58.85	5.50	82.08	12.42	14814	8559	6255	15200	1.43
96	Saar coal, Itzenplitz, Germany, Bunte	14.92	35.6	64.4	5.29	81.92	12.79	14075	9366	4709	13227	1.81
97	Darlington coal, Middle Kitaninny, Hoytdale, Pa., Lord & Haas	14.91	38.70	61.30	5.46	81.37	13.17	14900	8915	5985	15465	1.58
98	Bit., Indiana, U. S. A., Keyes, McTaggart & Craven	14.80										
99	Same as 97	14.76	39.62	60.38	5.34	78.92	14.74	14719	8780	5939	14985	1.52
100	Bit., Pittsburgh coal, Turtle Creek, Pa., Lord & Haas	14.75	40.58	59.42	5.55	81.89	12.56	14938	8642	6296	15515	1.46
101	Darlington coal, Middle Kitaninny, Beaver Creek, Pa., Lord & Haas	14.74	38.25	61.75	5.55	81.75	12.70	14722	8981	5741	15009	1.61
102	Saar coal, König, Germany, Bunte	14.74	41.0	59.0	5.65	83.32	11.03	14806	8581	6225	15183	1.44
103	Bit., Pittsburgh coal, Carnegie, Pa., Lord & Haas	14.70	39.32	60.68	5.59	82.07	12.34	14947	8824	6123	15570	1.54
104	Bit., r. of m., Pittsburgh Bed, Kingmont, W. Va., U.S.G.S. No. 1	14.70	40.01	59.99	5.61	85.65	10.74	15348	8725	6623	16553	1.50
105	Darlington coal, Middle Kitaninny, near Wampum, Pa., Lord & Haas	14.70	39.72	60.28	5.6	82.28	12.12	14839	8767	6072	15287	1.52
106	Upper Freeport coal, Yellow Creek, Ohio, Lord & Haas	14.69	43.21	56.79	5.48	80.54	13.98	14994	8260	6734	15584	1.31

TABLE LVI—*Continued*

COMBUSTIBLE AND VOLATILES OF COALS, LIGNITES, AND PEATS

No.	Name, Source, Size, Authority.	Combustible = Coal Less (Moisture + Ash.)									B.T.U. Lb. Vol. = B.T.U. Lb. Comb., Less C in Comb. × 14544 divided by Vol. in Comb.	Ratio of Fixed C. / Vol.
		Ratio of Total, C/H.	Proximate.		Ultimate.			B.T.U. per Pound.				
			Volatile, %	Fixed C, %	H_2 %	C %	O_2 N_2 S %	Total.	From Fixed C.	From Volatile.		
107	Bit., Pittsburgh coal, Turtle Creek, Pa., Lord & Haas	14.67	37.86	62.14	5.67	83.17	11.16	15080	9037	6043	15958	1.64
108	Lignitic flaming coal, Decazeville (Bourran), France, Mahler	14.64	39.4	60.6	5.64	81.53	12.83	14549	8813	5736	14556	1.54
109	Saar coal, Köhlwald, Germany, Bunte	14.61	39.6	60.4	5.57	81.37	13.06	13931	8783	5148	12995	1.53
110	Bit., r. of m., Straight Creek, Eastern Field, Ky., U.S.G.S. No. 1	14.6	39.04	60.96	5.62	81.94	12.44	15292	8865	6427	16460	1.56
111	Bit., r. of m., Wheatcroft, Western Field, Ky., U.S.G.S. No. 4	14.6	43.54	56.46	5.30	77.86	16.84	14835	8212	6623	15215	1.30
112	Upper Freeport coal, Palestine, O., Lord & Haas	14.55	40.99	59.01	5.52	80.26	14.22	14803	8582	6221	15177	1.44
113	Bit., lump and nut, Warrior Field, Horse Creek, Ala., U.S.G.S. No. 1	14.5	37.41	62.59	5.68	82.60	11.72	15100	9103	5997	16030	1.67
114	Bit., lump, nut, and pea, Warrior Field, Carbon Hill, Ala., U.S.G.S. No. 2	14.5	39.05	60.95	5.48	79.16	15.36	13911	8865	5046	12922	1.56
115	Bit., lump and nut, Pittsburgh, Bed W. Mineral, Kan., U.S.G.S. No. 5	14.50	37.08	62.92	5.56	80.6	13.84	14602	9151	5451	14701	1.70
116	Upper Freeport coal, East Palestine, Ohio, Lord & Haas	14.46	39.92	60.08	5.54	80.1	14.36	14603	8738	5865	14692	1.51
117	Same coal, Waterford, Ohio, Lord & Haas	14.45	41.18	58.85	5.59	80.7	13.71	14814	8559	6255	15189	1.43
118	Lignitic flaming coal, Blanzy Purts, Ste. Eugenie, France, Mahler	14.45	35.8	64.2	5.60	83.17	11.14	14886	9337	5549	15500	1.79
119	Bit., Creedmoor, Pa., Lord & Haas	14.45	43.21	56.79	5.72	82.68	11.60	14983	8260	6723	15559	1.31
120	Saar coal, Reden, Germany, Bunte	14.43	37.9	62.1	5.60	80.79	13.61	13891	9032	4859	12820	1.64
121	Bit., r. of m., Weir-Pittsburgh Bed, Clarksburg, W. Va., U.S.G.S. No. 2	14.40	44.28	55.72	5.52	80.83	13.65	15291	8104	7187	16231	1.26

122	Mahonny coal, Salineville, Ohio, Lord & Haas	14.37	40.72	59.28	5.56	79.83	14.61	14727	8622	6105	14993	1.46
123	Bit., Cambridge, Ohio, Lord & Haas	14.35	42.87	57.13	5.58	80.11	14.31	14473	8309	6164	14388	1.33
124	Darlington coal, Middle Kitaninny, Clinton, Pa., Lord & Haas	14.31	39.82	60.18	5.59	80.01	14.40	14719	8752	5967	14982	1.51
125	Bit., Hartshorne Bed, Hartshorne, Ind. Ter., U.S.G.S. No. 2	14.30	42.76	57.24	5.63	80.62	13.75	14910	8325	6585	15400	1.34
126	Upper Freeport coal, East Palestine, Ohio, Lord & Haas	14.26	41.99	58.01	5.58	79.62	14.81	15010	8437	6573	15654	1.38
127	Same	14.22	42.19	57.81	5.7	80.99	13.31	14863	8408	6455	15300	1.37
128	Upper Freeport coal, Steubenville, O., Lord & Haas	14.21	43.22	56.78	5.7	80.93	13.37	14881	8258	6623	15324	1.31
129	Pittsburgh coal, Carnegie, Pa., Lord & Haas	14.16	42.01	57.99	5.71	81.0	13.29	14846	8434	6412	15263	1.38
130	Pittsburgh coal, North Mansfield, Pa., Lord & Haas	14.16	40.74	59.26	5.66	81.27	13.17	14898	8619	6279	15412	1.45
131	Upper Freeport coal, Salineville, Ol., Lord & Haas	14.15	40.74	59.26	5.59	79.02	15.39	14688	8619	6069	14897	1.45
132	Upper Freeport coal, New Galilee, O., Lord & Haas	14.15	41.24	58.76	5.7	80.58	13.72	14697	8547	6150	14915	1.42
133	Pittsburgh coal, Creedmoor, Pa., Lord & Haas	14.11	43.21	56.79	5.78	81.69	12.53	14983	8260	6723	15561	1.31
134	Bit., r. of m., McAlester Bed, Edwards, Ind. Ter., U.S.G.S. No. 3	14.10	43.92	56.08	5.47	76.87	17.65	14623	8156	6467	14724	1.28
135	Saxon brown coal, Bach bei Ziebingen, Ger., Bunte	14.03	57.8	42.2	5.69	68.89	25.42	10134	6138	3996	6913	.73
136	Bit., lump, nut, slack, Weir, Pittsburgh Bed, Yale, Kan., U.S.G.S. No. 2	13.90	40.09	59.91	5.58	77.26	17.16	14943	8713	6230	15540	1.49
137	Lignitic flaming coal, Decazeville (Tramont), France, Mahler	13.89	41.23	58.77	5.67	78.72	15.61	14110	8548	5562	13490	1.42
138	Darlington coal, Middle Kitaninny, Wampum, Pa., Lord & Haas	13.85	42.44	57.56	5.76	79.85	14.39	14881	8372	6509	15337	1.36
139	Bit., Mary Lee (top), Ala., W. B. Phillips	13.77										
140	Bit., r. of m., Marion, Ill., U.S.G.S. No. 3	13.70	36.74	63.26	5.57	76.12	18.31	14679	9200	5479	14910	1.72
141	Lignite, Trifail (Styria), Mahler	13.68	50.34	49.66	5.06	69.24	25.71	11909	7223	4686	9311	.99
142	Upper Freeport coal, Cambridge, O., Lord & Haas	13.61	42.87	57.13	5.75	77.95	16.32	14474	8300	6165	14381	1.33
143	Lump and slack, Henryetta, Bed Ind. Terr., U.S.G.S. No. 1	13.60	41.65	58.35	5.73	77.92	16.35	14712	8486	6226	14948	1.40
144	Cannel gas coal, Niddrie, France, Mahler	13.51	....	....	6.57	83.80	9.63	......	......	......	....	.....
145	Lump and fine, Laddsvale, Wapello Co., Iowa, U.S.G.S. No. 1	13.40	40.58	59.42	5.52	74.03	20.45	12905	8642	4263	10505	1.46
146	Saxon brown coal, Greppen, Germany, Bunte	13.33	58.5	41.5	4.92	66.62	29.46	10540	6036	4504	7610	.71
147	Jackson Co., Ohio, West, Lord & Haas	13.30	38.24	61.76	6.08	80.84	13.08	14189	8982	5207	13617	1.62
148	Lignite, Vaurigard, France, Mahler	13.24	49.95	50.05	5.01	66.36	28.63	10937	7279	3658	7323	1.002
149	Bit., Osage River, Miss., Johnson	13.20										

TABLE LVI—*Continued*

COMBUSTIBLE AND VOLATILES OF COALS, LIGNITES, AND PEATS

No.	Name, Source, Size, Authority.	Combustible = Coal Less (Moisture + Ash.)									B.T.U. Lb. Vol. = B.T.U. Lb. Comb., Less C in Comb. × 14544 divided by Vol. in Comb.	Ratio of Fixed C. / Vol.
		Ratio of Total, C / H.	Proximate.		Ultimate.			B.T.U. per Pound.				
			Volatile, %	Fixed C, %	H_2 %	C %	O_2 N_2 S %	Total.	From Fixed C.	From Volatile.		
150	Upper Bavarian coal, Haushamer Grobkohle, Germany, Bunte	13.13	45.5	54.5	5.57	73.14	21.29	12759	7926	4833	10622	1.20
151	Lump, McAlester Bed, Lehigh, Ind. Ter., U.S.G.S. No. 4	13.10	46.26	53.74	5.59	72.99	21.42	13941	7816	6125	13240	1.16
152	Hocking Valley coal, lump, Middle Kitaninny, O., Lord & Haas	12.98	42.48	57.54	6.34	82.48	11.16	14166	8369	5797	13646	1.35
153	Jackson Co., Ohio, North, Lord & Haas	12.95	38.65	61.35	6.35	82.2	11.45	14162	8923	5239	13555	1.59
154	Lump, Atchison Field, Atchison, Kan., U.S.G.S. No. 4	12.90	44.2	55.8	5.77	74.42	19.81	14721	8116	6605	14943	1.26
155	Jackson Co., Ohio, Center, Lord & Haas	12.90	40.1	59.89	6.32	81.55	12.13	14078	8710	5368	13386	1.49
156	R. of m., Rich Hill Field, Sprague, Mo., U.S.G.S. No. 1	12.90	46.44	53.56	5.83	75.36	19.04	14640	7790	6850	14750	1.15
157	Hocking Valley coal, r. of m., Middle Kitaninny, O., Lord & Haas	12.88	40.80	59.20	6.43	82.78	10.79	13972	8610	5362	13142	1.45
158	Bit., Lancaster, Ind., Noyes, McTaggart & Craven	12.84	44.22	55.78	5.71	73.28	21.15	12573	8113	4460	10088	1.26
159	Jackson Co., Ohio, South, Lord & Haas	12.77	42.58	57.42	6.42	81.99	11.59	14148	8351	5797	13615	1.35
160	Same, Eastern District	12.75	39.8	60.2	6.35	81.05	12.60	13006	8755	4251	10681	1.51
161	Hocking Valley coal, lump, Middle Kitaninny, O., Lord & Haas	12.72	42.36	57.64	6.58	83.66	9.76	13905	8383	5522	13036	1.36
162	Lump and nut, Earlington, Ky., Western Field, U.S.G.S. No. 2	12.70	45.73	54.27	5.88	71.65	19.47	14441	7893	6548	14319	1.18
163	Bit., New Pittsburgh, Ind., Noyes, McTaggart & Craven	12.62	49.99	50.01	5.85	72.53	24.83	13943	7273	6670	13343	1.002
164	Same as 162, r. of m., U.S.G.S. No. 3	12.60	44.00	56.00	5.87	74.41	19.72	14657	8145	6512	14800	1.27
165	R. of m., Barnett, Morgan Co., Mo., U.S.G.S. No. 4	12.60	50.25	49.75	6.09	76.45	17.46	15134	7236	7898	15717	.99
166	Saxon brown coal, Alfred, Germany, Bunte	12.58	58.9	41.1	5.81	73.08	21.11	11884	5978	5906	10027	.697

167	Upper Bavarian coal, Penzberger Förderkohle, Germany, Bunte	12.48	51.2	48.8	5.65	70.50	23.85	12509	7097	5412	10570	.953
168	R. of m., Hamilton, Marion Co., Ia., U.S.G.S. No. 2	12.40	47.17	52.83	5.83	72.72	21.45	14246	7683	6563	13911	1.12
169	R. of m., Coffeen, Montgomery Co., Ill., U.S.G.S. No. 6	12.30	40.78	59.22	5.72	70.96	23.32	13923	8613	5310	13021	1.45
170	R. of m., Booneville, Warwick Co., Ind., U.S.G.S. No. 2	12.30	46.72	53.28	5.91	72.81	21.28	14377	7749	6628	14186	1.14
171	Lump, Altoona, Polk Co., Iowa, U.S.G.S. No. 3	12.30	51.23	48.77	5.84	81.76	22.40	14203	7093	7110	13878	.952
172	Lump and nut, Belleville Field, O'Fallen, Ill., U.S.G.S. No. 1	12.20	48.66	51.34	5.90	71.87	22.23	13933	7476	6466	13288	1.055
173	R. of m., Cambria, Field, Cambria, Wyo., U.S.G.S. No. 2	12.20	50.14	49.86	5.84	71.12	23.04	13817	7252	6565	13093	.994
174	Saxon brown coal, Marie Louise, Germany, Bunte.	12.17	56.5	43.5	5.88	71.57	22.55	12203	6327	5876	10400	.769
175	Saxon brown coal, Menselwitz Fortschritt, Germany, Bunte	12.10	57.80	42.2	5.69	68.89	25.42	11318	6137	5181	8963	.73
176	R. of m., Mildred, Sullivan Co., Ind., U.S.G.S. No. 1	11.90	44.96	55.04	6.03	72.17	21.80	13030	8005	5025	11176	1.22
177	Lump, Belleville Field, Troy, Ill., U.S.G.S. No. 4	11.60	42.28	57.72	6.05	70.10	23.85	14216	8395	5821	13768	1.365
178	Lignite, Terre de Feu, France, Mahler	11.59	52.77	47.23	5.94	71.01	23.05	12670	6869	5801	10993	.895
179	Lump, Centerville, Appanoose Co., Iowa, U.S.G.S. No. 4	11.50	47.50	52.50	6.00	69.19	24.81	14303	7635	6668	14036	1.105
180	Black lignite, washed nut, Red Lodge, Mont., U.S.G.S. No. 1	11.50	46.03	53.97	5.92	68.04	26.04	13516	7849	5667	13212	1.17
181	Lignite, Josefszeche in Schwanenkirchen, Germany, Bunte	11.39	58.6	41.4	5.81	65.81	28.38	10366	6021	4345	7415	.706
182	R. of m., Bevier Field, Mo., U.S.G.S. No. 2	11.30	46.95	53.05	6.00	68.03	25.99	15245	7716	7529	16036	1.15
183	R. of m., Charlton, Lucas Co., Iowa, U.S.G.S. No. 5	11.20	42.35	57.55	6.19	69.28	24.53	14228	8384	5844	13797	1.36
184	Black lignite, lump and slack, Gallop Field, New Mexico, U.S.G.S. No. 1	11.20	42.83	57.17	6.17	69.33	24.60	13938	8315	5623	13129	1.334
185	Same, slack, U.S.G.S. No. 2	11.20	47.93	51.80	7.03	70.29	22.33	14081	7534	6547	13659	1.08
186	Lignite, Presstorf von Hofmark, Steinfels, Germany, Bunte	11.00	66.80	33.2	5.73	63.02	31.25	10038	4829	5209	7798	.497
187	Brown lignite, Hoyt, Wood Co., Tex., U.S.G.S. No. 2	10.90	49.56	50.44	5.85	63.55	30.60	12453	7336	5117	10325	1.017
188	Black lignite, Boulder Field, Lafayette, Colo., U.S.G.S. No. 1	10.60	46.31	53.69	6.14	65.29	28.57	13465	7808	5657	12213	1.16
189	Peat of Pschorrschwaige, Germany, Bunte	10.59	64.50	35.50	5.72	60.61	33.67	9242	5163	4081	6324	.55
190	Brown lignite, Lehigh Field, N. Dak., U.S.G.S. No. 1	10.10	53.54	46.46	5.96	59.99	34.05	12525	6757	5768	10773	.867

TABLE LVI—*Concluded*

COMBUSTIBLE AND VOLATILES OF COALS, LIGNITES, AND PEATS

No.	Name, Source, Size, Authority.	Combustible = Coal Less (Moisture + Ash.)									B.T.U. Lb. Vol. = B.T.U. Lb. Comb., Less C in Comb. × 14544 divided by Vol. in Comb.	Ratio of $\frac{\text{Fixed C.}}{\text{Vol.}}$
		Ratio of $\frac{\text{Total. C.}}{\text{H.}}$	Proximate.		Ultimate.			B.T.U. per Pound.				
			Volatile, %	Fixed C, %	H_2 %	C %	$\left.\begin{matrix}O_2\\N_2\\S\end{matrix}\right\}$ %	Total.	From Fixed C.	From Volatile.		
191	Brown lignite, Williston Field, N. Dak., U.S.G.S. No. 2	9.80	48.44	51.56	6.01	59.13	34.86	12391	7499	4892	10099	1.064
192	Peat of Ostrach, Germany, Bunte	9.78	65.6	34.4	5.84	57.11	37.05	8937	5003	3934	5997	.524
193	Black lignite, Sheridan Field, Wyo., U.S.G.S. No. 1	9.60	48.97	51.03	6.39	61.35	33.31	13357	7422	5935	12120	1.04
194	Bohemian peat, Mahler	9.60	68.93	31.07	5.96	57.21	36.82	10625	4519	6106	8858	.45
195	Brown lignite, Houston Co., Tex., U.S.G.S. No. 1	9.40	59.58	40.42	6.54	61.14	32.32	....	5879	....	......	.678
196	Cannel coal, Obertite, Nova Scotia, Kent	9.04										
197	Oak wood, Mahler	8.57	....	....	5.88	50.44	43.69	8440	....	....	......	.....
198	Norway pine, Mahler	8.48	....	....	6.02	51.08	42.90	8690	....	....	......	
199	Cannel coal, Tasmanite, Tasmania, Kent	7.62										.....
200	Cellulose, Mahler	7.20	....	....	6.17	44.44	49.39	7560	....	....	......	.....

Table LVII

CLASSIFICATION OF COALS BY GAS AND COKE QUALITIES

Behavior of Powdered Sample on Heating in Crucible.	Muck.						Sexton's English Names.	Grüner's German Names.	Hilt.	
	Name.	Class.	Ash and Moisture Free. C	H_2	O_2	Per Cent Coke.			Name.	$\frac{\text{Fixed C}}{\text{Volatile}}$ Ash and Moisture Free
Does not melt, residue powder, same as coal.	Sand coal.	Anthracite and semi - anthracite.	93 to 90	4 to 4.5	3 to 5.5	90 to 82	Anthracite	Lean coal	Anthracite	20 to 9
Partly melts, residue mainly powder, rest soft.	Molten sand coal.	Dry bituminous, long flame.	80 to 75	4.5 to 5.5	15 to 19.5	60 to 50	Non - caking coal, long flame	Dry coal, long flame	Semi - caking sinter coal, poor in gas	9 to 5.5
Melts, residue compact and hard but not puffed.	Sinter coal.	Caking bituminous coal, long flame gas coal.	85 to 80	5 to 5.8	10 to 14.2	68 to 60	Gas coal	Fat coal, long flame	Caking or coking coal	5.5 to 1.2
									Caking gas coal	1.2 to 1.5
Melts, residue compact and hard somewhat puffed.	Caking, sinter coal.	Caking coal, proper, or forge coal.	89 to 84	5.5 to 5.0	5.5 to 11	74 to 68	Furnace coal	Fat caking coal	Sinter coal, rich in gas	1.5 to 1.25
Melts thoroughly, residue very hard and very much puffed.	Caking coal.	Caking bituminous coal	91 to 88	4.5 to 5.5	5.5 to 6.5	82 to 74	Coking coal	Fat coal, short flame	Sand coal, rich in gas	1.25 to 1.1

TABLE LVIII

PARAFFINES (C_nH_{2n+2}) FROM PENNSYLVANIA PETROLEUM

	Name.	Formula.	Boiling-point. ° C.	Boiling-point. ° F.	Specific Gravity at 32° F.	Molecular Weight Approx.	Composition by Weight. % C.	Composition by Weight. % H.
Gas	Methane	CH_4	....	.....	....	16	75	25
	Ethane	C_2H_6	....	.....	.446	30	80.12	19.98
	Propane	C_3H_8	−25	−13	.536	44	81.84	18.16
	Butane	C_4H_{10}	0	32	.60	58	82.76	17.24
	Pentane normal	C_5H_{12}	38	100.4	.627 at 57 .628	72	83.33	16.67
Liquid	Pentane iso	C_5H_{12}	30	86	.658 at 68	72	83.33	16.67
	Hexane normal	C_6H_{14}	69	156.2	.664	86	83.76	16.24
	Hexane iso	C_6H_{14}	61	141.8	.683 at 68	86	83.76	16.24
	Heptane normal	C_7H_{16}	97.5	207.5	.699	100	84.00	16.00
	Heptane iso	C_7H_{18}	91	195.8	.702 at 68	100	84.00	16.00
	Octane normal	C_8H_{18}	125	257	.703	114	84.21	15.79
	Octane iso	C_8H_{18}	118	224.4	.718 at 68	114	84.21	15.79
	Nonane	C_9H_{20}	136	276.8	.741	128	84.38	15.62
	Decane	$C_{10}H_{22}$	173	343.4	.73 at 68 .757	142	84.51	15.49
	Endecane	$C_{11}H_{24}$	182	359.6	.774 at −15 .765	156	84.62	15.38
	Dodecane	$C_{12}H_{26}$	198	388.4	.773 at −10 .776	170	84.71	15.29
	Tridecane	$C_{13}H_{28}$	216	420.8	.792	184	84.78	15.22
	Tetradecane	$C_{14}H_{30}$	238	460.4	.775 at 39	198	84.85	15.15
	Pentadecane	$C_{15}H_{32}$	258	496.4	....	212	84.92	15.08
	Hexadecane	$C_{16}H_{34}$	280	536.	.775 at 64	226	84.96	15.04
	Octodecane	$C_{18}H_{38}$	....	.....	....	254	85.02	14.98
	Eicosane	$C_{20}H_{42}$	205	401.	.778 at 99	282	85.10	14.90
	Tricosane	$C_{23}H_{48}$	234	453.	.779 at 118	324	85.18	14.82
		$C_{25}H_{62}$	....	.....	....	352	85.23	14.77
Solid	Paraffine (myricle)	$C_{27}H_{68}$	....	.....	....	380	85.26	14.74
	Paraffine (ceryl)	$C_{30}H_{62}$	370	698	....	422	85.31	14.69

ETHYLENES (C_nH_{2n}) AND NAPHTHALENES ($C_nH_{2n-6}+H_6$) FROM RUSSIAN PETROLEUM

Ethylenes Naphthalenes.	Formula.	° C.	° F.	Specific Gravity at 32° F.	Molecular Weight Approx.	% C.	% H.
Ethylene	C_2H_4	gas	.....	....	28	85.7	14.3
Propylene	C_3H_6	gas	.....	....	42	85.7	14.3
Butylene	C_4H_8	1	33.8	.635	56	85.7	14.3
Amylene	C_5H_{10}	36	96.8	....	70	85.7	14.3
Hexylene	C_6H_{12}	70	158	.76	84	85.7	14.3
Heptylene	C_7H_{14}	84	183.2	.714	98	85.7	14.3
Octylene	C_8H_{16}	119	246.2	.733	112	85.7	14.3
Oct. Naphthalene	$C_8H_{10}+H_8$	136	276.5	.771	106+6	85.7	14.3
Nonylene	C_9H_{18}	....	.....	....	126	85.7	14.3
Diamylene	$C_{10}H_{20}$	161	321.8	.777	140	85.7	14.3
	$C_{11}H_{22}$	180	356	....	154	85.7	14.3
	$C_{12}H_{24}$	....	.....	....	168	85.7	14.3
Dodeca Naphthalene	$C_{12}H_{18}+H_8$	196	384.8	.803	162+6	85.7	14.3
	$C_{14}H_{28}$	240	464.	....	196	85.7	14.3
Triamylene	$C_{15}H_{30}$	248	478.4	....	210	85.7	14.3
Tetraamylene	$C_{20}H_{40}$	over 390	over 734	....	280	85.7	14.3

Table LIX

CALORIFIC POWER OF MINERAL OILS BY CALORIMETER AND CALCULATION BY DENSITY FORMULA OF SHERMAN AND KROPFF

No.	Class of Oil.	Sp.gr. at 15° C.	Degree Bé.	B.T.U. per Pound. Calorimeter.	B.T.U. per Pound. Calcul. S.&K.Form.	Error. %
1	Gasolene	.71	67.2	21120	20938	− .91
2	Gasolene	.7175	65.1	20389	20854	+2.33
3	Gasolene	.72	64.4	20527	20726	+ .99
4	Gasolene	.7709	51.6	20038	20314	+1.38
5	Kerosene	.7830	48.8	20018	20206	+ .92
6	California, refined	.7850	48.35	20014	20194	+ .89
7	West Virginia, crude	.7945	46.2	20030	20098	+ .33
8	Kerosene	.795	46.1	20135	20094	− .20
9		.7964	45.8	20236	20082	− .76
10	Ohio, crude	.8048	44.0	20068	20010	− .29
11	Pennsylvania, crude	.8059	43.7	20057	19998	− .29
12	California, refined	.8080	43.2	19802	19979	+ .88
13	Kansas, refined	.8103	42.8	19963	19962	± .00
14	West Virginia, crude	.8237	40.0	19766	19850	+ .42
15	California, refined	.8248	39.7	19827	19838	+ .05
16	West Virginia, crude	.8261	39.5	20021	19830	− .05
17		.8321	38.2	19757	19778	+ .11
18	Pennsylvania, crude	.8324	38.2	19782	19778	− .02
19	Ohio	.8418	36.3	19710	19702	− .04
20	Indian Territory	.8421	36.25	19795	19698	− .48
21		.8436	36.0	19924	19690	−1.17
22	Indian Territory	.8466	35.4	19685	19666	− .09
23	California, refined	.8500	34.7	19715	19638	− .38
24	Kansas, crude	.8510	34.5	19724	19630	− .47
25		.8514	34.45	19701	19630	− .35
26		.8534	34.05	19784	19610	− .86
27	Kansas, crude	.8580	33.20	19389	19578	+ .95
28	Illinois, crude	.8597	32.8	19379	19562	+ .95
29		.8616	32.5	19741	19550	− .95
30	California, refined	.8640	32.05	19555	19530	− .12
31	Pennsylvania, fuel oil	.8648	31.9	19656	19526	− .65
32		.8660	31.65	19555	19516	− .19
33	Pennsylvania, fuel oil	.8670	31.5	19530	19510	− .10
34	Indian Territory	.8690	31.1	19534	19494	− .20
35		.8708	30.8	19654	19482	− .86
36		.8712	30.7	19614	19478	− .68
37	Kansas, crude	.8745	30.1	19354	19454	+ .50
38	Pennsylvania, fuel oil	.8773	29.6	19428	19434	+ .03
39	Kansas, crude	.8800	29.0	19447	19410	− .18
40		.8807	29.0	19435	19410	− .47
41		.8810	28.9	19435	19406	− .15

TABLE LIX—*Continued*

CALORIFIC POWER OF HYDROCARBON OILS BY CALORIMETER AND CALCULATION BY DENSITY FORMULA OF SHERMAN AND KROPFF

No.	Class of Oil.	Sp.gr. at 15 °C.	Degrees Bé.	B.T.U. per Pound.		Error, %
				Calorimeter.	Calcul. S.&K. Form	
42	....	.8820	28.75	19643	19400	−1.22
43	Kansas, crude...............	.8828	28.7	19249	19396	+ .73
44	....	.8833	28.5	19474	19390	− .42
45	Indian Territory.............	.8860	28.0	19454	19370	− .42
46	....	.8862	28.0	19372	19370	− .01
47	Indian Territory.............	.8900	27.3	19418	19342	− .39
48	Texas, crude................	.8914	27.1	19242	19332	+ .45
49	....	.8970	26.1	19355	19294	− .31
50	....	.9007	25.4	19359	19267	− .47
51	....	.9050	24.7	19228	19238	+ .05
52	....	.9065	24.45	19352	19228	− .63
53	Kansas, crude...............	.9066	24.4	19089	19226	+ .69
54	....	.9087	24.1	19282	19213	− .35
55	Kansas, crude...............	.9114	23.6	19303	19194	− .55
56	Texas, crude................	.9137	23.2	19028	19178	+ .76
57	Texas, crude................	.9153	22.95	19246	19168	− .39
58	Texas, crude................	.9155	22.9	19008	19166	+ .80
59	California, crude............	.9158	22.9	18572	19166	+2.58
60	Fuel oil.....................	.9170	22.7	19103	19157	+ .28
61	California, crude............	.9179	22.5	18779	19150	+1.94
62	California, crude............	.9182	22.5	18985	19149	+ .83
63	Texas, crude................	.9336	20.0	19080	19048	− .16
64	California, crude............	.9644	15.2	18589	18858	+1.42

TABLE LX

PROPERTIES OF OIL GAS

No.	Description.	Volumetric Analysis.							At 32° F. and 29.92″ Hg Pressure.					
		CH_4	H_2	Heavy C_2H_4	CO.	CO_2.	O_2	N_2	Lbs. Cu. Ft.	Cu. Ft. per Lb.	B.T.U. per Cu. Ft.		B.T.U. per Lb.	
											High.	Low.	High.	Low.
1	Thwaite oil gas....	63.19	31.61	...	.4	..	..	5.06	.03427	29.18	893.5	818.0	26072	23869
2	Pintsch American oil	63.1	5.6	27.4	.4	..	.8	..	.05142	19.45	1173.	1074.	22815	20889
3	Pintsch American oil	61.2	6.4	28.3	.2	..	.7	..	.05109	19.6	1260.7	1064.	24710	20854
4	Oil gas............	58.3	24.3	17.4	..	.9	..	..	.04313	23.2	995.9	803.9	23096	18650
5	Pintsch gas from petroleum residue	58.0	24.3	17.	..	..	..	..	.04081	24.5	990.2	898.	24260	22000
6	Pintsch gas from paraffine oil.......	54.9	5.6	28.9	8.9	.9	..	..	.0591	16.92	1126.8	1034.8	19065	17509
7	American petroleum oil gas..........	53.7	4.8	41.2	.2	..	..	.1	.05726	17.46	1294.8	1192.0	22607	20812
8	Pintsch gas, Moorehead............	52.5	18.5	23.5	1.0	.5	.5	3.5	.04777	17.32	1157.5	966.5	20060	16940
9	General...........	48.	32.	16.5	..	..	5.0	3.0	.04318	23.16	901.3	716.	20874	16583
10	Crude oil Retort gas, England.........	35.4	6.6	49.4	1.5	1.4	.3	..	.05972	16.750	1390.7	1107.	23282	18542
11	English shale oil gas, Young and Bell...	19.	16.85	44.83	.63	..	.24	1.15	.04670	21.41	1043.1	966.0	22333	20682

The hydrocarbon analyses in this table for oil gas are quite uncertain, but less so than the hydrocarbons equivalent to kerosene and gasolene.

Table LXI

COMPOSITION OF NATURAL GASES

No.	Source.	Authority	Volumetric Analysis.							
			O_2.	CH_4.	C_2H_6.	H_2.	CO.	C_2H_4.	N_2.	CO_2.
1	West Virginia......	Report Gas Eng. Com. N. E. L. A...	.4	99.5	.1					
2	Kansas............	Report Gas Eng. Com. N. E. L. A...	.25	98.3	...	...	.25	...	1.2	
3	Caucasus..........	Bunsen...........	..	97.57	...	...	2.69			
4	Caucasus..........	Bunsen...........	..	95.56	...	...	4.4			
5	Kokomo, Ind.......	Levin............	.3	94.16	...	1.7	.55	.3	2.8	.29
6	Kokomo, Ind.......	Eng. & M. J.......	.3	94.16	...	1.42	.55	.3	2.8	.29
7	St. Mary's, Ohio...	Levin............	.35	93.85	...	2.74	.44	.2	2.98	
8	....	Lucke............	.35	93.85	...	2.14	.44	.2	2.98	
9	Marion, Ind.......	Eng. & M. J.......	.55	93.57	...	1.2	.6	.15	3.42	.3
10	Marion, Ind.......	Levin............	.55	93.57	...	1.4	.6	.15	3.42	.3
11	Findlay, Ohio......	Eng. & M. J.......	.39	93.35	...	1.64	.41	.35	3.41	.25
12	Findlay, Ohio......	Levin............	.39	93.35	...	1.84	.41	.35	3.41	
13	English...........	Lewes............	..	93.16	2.94	...	1.0	...	2.9	
14	Russian...........	Lewes............	..	93.1	3.26	.98	..	...	1.9	2.18
15	Caucasus..........	Bunsen...........	..	93.09	3.26	.98	..	...	.49	2.18
16	Anderson, Ind.....	Eng. & M. J.......	.42	93.07	...	1.86	.73	.47	3.02	.26
17	Anderson, Ind.....	Levin............	.42	93.07	...	2.01	.73	.47	3.02	.26
18	Ohio.............	Lewes............	.35	92.84	.35	1.89	..	...	3.82	.75
19	Fostoria, Ohio......	Eng. & M. J.......	.35	92.84	...	1.89	.55	.20	3.82	.20
20	Muncie, Ind.......	Levin............	.35	92.67	...	2.5	.4	.25	3.53	
21	Muncie, Ind.......	Eng. & M. J.......	.35	92.67	...	2.35	.45	.25	3.53	.25
22	Findlay, Ohio......	Gill..............	.3	92.6	...	2.3	.5	.3	3.5	.3
23	....	Lucke............	.34	92.6	...	2.18	.5	.31	3.61	2.6
24	Caucasus..........	Bunsen...........	..	92.49	4.11	.94	.93	...	2.13	
25	Caucasus..........	Bunsen...........	..	92.24	4.26	...	3.50			
26	Leechburg, Pa.....	Hoyle............	..	89.65	...	4.79	.26	4.39	...	.35
27	Penna. & W. Va....	Allen & Burrell.....	..	83.	16.4	...	..	...	.6	
28	West Virginia......	Report Gas Eng. Com. N. E. L. A...	.15	81.5	17.6	.2	..	...	.55	
29	Butler County, Pa..	Hoyle............	..	80.11	...	13.5	..	5.72	...	.66
30	Butler County, Pa..	Hoyle............	..	75.44	...	6.1	..	18.12	...	.34
31	U. S..............	Ford.............	1.1	72.18	.7	20.6	1.	...	...	.8
32	Pittsburgh, Pa.....	Levin............	.8	72.18	...	20.	1.	3.0	...	.8
33	Penna............	Jüptner..........	..	67.0	5.0	22.	.6	1.0	3.0	.6
34	Pittsburgh, Pa......	Hoyle............	.8	67.0	...	22.	.6	5.0	3.0	.6
35	U. S..............	Ford.............	.8	65.75	1.	26.12	.8	...	...	.6
36	U. S..............	Ford.............	.78	60.7	1.	29.03	.58			
37	U. S..............	Ford.............	2.1	57.85	.8	9.64	1.0	...	23.41	
38	U. S..............	Ford	.8	49.58	.6	35.92	.4	12.3	...	.4

Table LXII

PROPERTIES OF MINERAL OILS

No.	Name and Source.	Density.			Ultimate Analysis.				Prox. H_2O.	B.T.U. per Pound.			
		Sp.Gr.	°F.	°Bé.	C.	H_2.	O_2+N_2.	S.		By Calorimeter.	By S. & K. Form	High Value.	Low Value.
1	Coal tar, Paris gas works	1.044	....	6.112	82	7.6	....	....	....	.....	18595	16533	15870
2	Ogaio, crude	.985	32	12.135	87.1	10.4	2.5	....	....	18146	18735	18983	18065
3	California, fuel	.966	60	14.93	81.52	11.61	6.92	.55	....	18667	18847	18926	17903
4	California, Whittier	.9637	60	15.28	....	....	....	.845	8.71	18518	18861		
5	California, Whittier	.9629	60	15.39	....	....	....	.84	8.82	18596	18866		
6	California and Bakersfield fuel	.962	60	15.53	84.43	10.99	3.99	.59	....	.....	18871	18976	18005
7	Barbadoes fuel	.958	....	16.114	....	....	....	....	....	17718	18894		
8	California crude	.9572	60	16.24	86.3	16.7	....	.8	....	18646	18900	21723	21254
9	Russian residue	.956	....	16.43	....	....	....	....	....	19440	18907		
10	Hanover	.955	32	16.505	86.2	11.4	2.4	....	....	.....	18910	19488	18493
11	California crude	.9533	60	16.85	85.75	11.3	....	.67	....	18797	18924	19356	18363
12	California, Whittier and Los Angeles	.953	60	16.9	....	....	....	.98	4.93	18714	18926		
13	California, Whittier and Los Angeles	.9529	60	16.915	....	....	....	.955	4.62	18754	18926		
14	Texas fuel	.945	....	18.155	....	....	....	....	....	19242	18976		
15	California	.943	60	18.47	....	....	....	.735	1.06	18677	18989		
16	California, Whittier	.9417	60	18.67	....	....	....	.975	1.06	18626	18997		
17	California	.9410	60	18.783	....	....	....	1.010	.74	18705	19001		
18	California	.9407	60	18.829	....	....	....	.96	.42	18657	19003		
19	Baku Russia heavy	.938	60	19.26	86.6	12.3	1.1	....	....	19440	19021	20052	18978
20	Borneo	.936	....	19.58	....	....	....	....	....	18831	19033		
21	Baku, Russia residue	.928	60	20.95	87.1	11.7	1.2	....	....	22628	19088	19761	18739
22	Petroleum residue, Baku	.928	32	20.95	87.1	11.7	1.2	....	....	19832	19088	19761	18739
23	Petroleum residue, Baku	.928	....	20.95	87.1	11.7	1.2	....	....	19260	19088	19761	18739
24	Texas, Beaumont fuel	.926	60	21.25	83.26	12.41	3.83	.5	....	.....	19100	19654	18570
25	Texas, Beaumont crude	.924	60	21.56	84.60	10.90	2.87	1.63	....	.....	19112	18977	18025
26	Java	.923	60	21.71	87.1	12	.9	....	....	19496	19119	19943	18095

27	Texas, Beaumont	.920	60	22.17	86.8	13	.0	....	....	.....	19136	20505	19370
28	California	.920	60	22.17	84.0	12.7	1.2	....	....	.....	19136	19917	18807
29	Bumah fuel	.920	....	22.17	....	....	....	....	....	18864	19136		
30	Pennsylvania	.914	70	23.18	86.1	13.9	.....	.06	....	.....	19176	20949	19735
31	Texas, Beaumont, Richardson & Wallace	.912	70	23.514	85.03	12.3	.92	1.75	....	.....	19191	19894	18810
32	Pechelbronn	.912	32	23.514	86.9	11.8	1.3	....	....	17474	19191	19792	18761
33	Pechelbronn	.912	....	23.514	86.9	11.8	1.3	....	....	17816	19191	19792	18761
34	Shale oil, Ardeche	.911	....	23.682	80.3	11.5	8.2	....	....	16283	19196	18452	17647
35	Hanover crude	.892	32	26.95	80.4	12.7	6.9	....	....	.....	19328	19393	18283
36	Pechelbronn	.892	....	26.95	85.7	12	2.3	....	....	18036	19328	19739	18691
37	Ohio distillate	.887	60	27.84	84.2	13.1	2.7	....	....	18718	19364	20188	19044
38	Pennsylvania, crude, heavy	.886	32	28.01	84.9	13.7	1.4	....	....	19210	19370	20654	19457
39	Pennsylvania, heavy	.886	60	28.01	84.9	13.7	1.04	....	....	19224	19370	20654	19457
40	American residue	.886	32	28.01	....	....	....	....	....	19627	19370		
41	West Galicia	.885	32	28.095	85.3	12.6	2.1	....	....	18416	19374	20045	18944
42	Russian, crude, light	.884	32	28.38	86.3	13.6	.1	....	....	22628	19385	20796	19608
43	Balachany	.882	32	28.73	87.4	12.5	.1	....	....	21060	19400	20289	19198
44	Shale oil	.875	....	30.005	....	....	....	....	....	18217	19450		
45	West Virginia, heavy	.873	60	30.37	83.5	13.3	3.2	....	...	.....	19464	20207	19046
46	Calicia, Austria	.870	60	30.92	82.2	12.1	5.7	...	....	18416	19487	19291	18235
47	East Galicia	.870	32	30.92	82.2	12.7	5.7	....	....	18153	19487	19675	18545
48	Kansas, crude	.866	60	31.67	85.4	13.07	....	....	....	.....	19517	20345	19203
49	Schwabweiler	.861	32	32.603	86.2	13.3	.5	....	....	18844	19555	21200	19439
50	Baku, light	.844	....	35.87	86.3	13.6	....	....	....	20628	19685	20796	19608
51	West Virginia, light	.8412	....	36.435	84.3	14.1	1.6	....	....	18502	19705	20809	19578
52	West Virginia, crude	.841	60	36.47	84.3	14.1	1.6	....	....	18400	19709	20809	19578
53	West Virginia, light	.841	60	36.47	84.3	14.1	1.6	....	....	21240	19709	20809	19578
54	Ohio distillate	.838	60	37.07	....	....	....	....	....	19880	19733		
55	Schwabweiler	.829	32	38.89	79.5	13.6	6.9	....	....	.....	19806	19808	18620
56	Ohio, Mabery Noble	.829	70	38.89	85.0	13.8	.6	.6	....	.....	19806	20752	19547
57	Pennsylvania, crude	.826	60	39.50	82	14.8	3.2	....	....	17930	19830	20699	19606
58	Balakhany	.822	....	40.32	87.4	12.5	.1	....	....	21600	19863	19289	19198
59	American petroleum	.82	....	40.73	83.4	14.7	1.9	....	....	17588	19879	20042	19758
60	Pennsylvania, light	.816	....	41.57	82.0	14.8	3.2	....	....	17533	19913	19899	19606
61	Parma, Italy	.786	60	48.13	84	13.4	1.8	....	....	18215	20175	20341	19171
62	Parma, crude	.786	32	48.13	84	13.4	1.8	....	....	18218	20175	20341	19171
63	American, crude	....	....	....	83	14.4	3	....	....	19980	.....	20801	19544
64	American, refined	....	....	.....	85.5	14.2	.3	....	....	19883	.....	21045	19806
65	American, heavy residue	....	....	.....	87	13	....	....	....	19620	.....	20536	19401
66	Ohio, crude	....	60	.....	80.2	17.1	2.7	....	....	21600	.....	22031	20538

Table LXIII

COMPOSITION OF COKE OVEN AND RETORT COAL GAS

† Robinson

No.	Description.	Volumetric Analysis.								
		H_2	CH_4.	CO.	C_2H_4.	C_6H_6.	Heavy Hydro-carbons.	CO_2.	O_2	Re-mainder and N_2
1	Retort gas, Wright, 5½ hrs	67.12	22.58	6.12	.....	.....	1.79	1.50	.....	0.89
2	Wigan cannel coal, retort gas, Henry, 13th hr	60.0	20.0	10.00	.....	.....	0	.....	.....	10.0
3	Solvay coke oven	56.9	22.6	8.7	.....	.....	3.0	3.0	.....	5.8
4	Coke oven gas, average German, 1% water vapor	55.0	32.0	7.0	1.5	.8	.....	1.2	.....	2.5
5	Magdeburg retort gas	54.9	30.1	7.7	.....	.....	3.3	1.4	.2	2.4
6	Retort coal gas, Lewes, 5–6.5 O in coal	54.21	34.37	6.68	2.48	.79	.....	1.47		
7	Aachen retort gas	54.0	34.2	5.2	.....	.....	3.3	1.1	.....	2.2
8	† Norwich retort gas, bit. coal	53.79	36.11	3.40	.....	.....	3.26	.27	.14	3.03
9	† Southampton retort gas, bit. coal	53.59	36.74	3.59	.....	.....	3.09	.07	.39	2.53
10	† London retort gas, bit. coal	53.14	36.55	4.11	.....	.....	2.92	.09	.....	3.19
11	Coke-oven gas	53.0	35.0	6.00	2.0	.....	.....	2.0	.....	2.0
12	Common coal gas	52.9	31.8	7.18	5.0	.....	.....	.....	.....	3.12
13	Retort coal gas, Lewes, 6.5–7.5 O in coal	52.79	34.43	7.19	3.02	.99	.....	1.58		
14	Manchester Canal coal retort gas, Wright	52.71	31.05	4.47	.....	.....	11.19	.58		
15	Retort gas, Wright, 3½ hrs	52.68	33.54	6.21	.....	.....	3.04	1.49	.....	3.04
16	Average retort coal, Klumpp	52.5	31.35	8.6	.....	.....	1.3–2.2	1.5	.35	.35–1.05
17	Common coal gas	52.5	34.0	5.0	4.0	.....	.....	.....	.05	4.45
18	Retort coal gas, Sexton	51.88	31.8	9.1	.....	.....	5.2	.....	.....	2.02
19	† Brighton retort gas, bit, coal	51.62	38.15	4.14	.....	.....	3.76	.03	.23	2.07
20	London coal retort gas, Pryce	50.7	37.8	4.1	.....	.....	4.4	.....	.....	3.0
21	Retort coal gas, Newton, Mass.	50.59	34.80	6.16	.....	.....	5.23	1.16	.....	2.06
22	† Newcastle, Tyne, retort gas, bit. coal	50.5	36.71	3.37	.....	.....	3.62	.28	.23	5.29
23	Retort coal gas, Lewes, 7.5–9 O in coal	50.1	35.03	8.21	3.98	.66	.....	1.72	.....	.30
24	Paris retort gas	50.1	33.1	6.3	.....	.....	5.8	1.5	.50	2.7
25	Common coal gas	50.1	38.0	6.0	4.0	.....	.....	.....	.....	1.9
26	Coke oven gas, Wyer	50.0	36.0	6.0	4.0	.....	.....	1.5	.50	2.0

27	Laclede Gas Co., bit. coal	49.8	32.3	6.7	.....	.....	8.0	2.40	.60	0.2
28	Frankfurt retort gas	49.8	32.6	8.8	.....	.....	4.0	2.3	.....	2.5
29	Berlin retort gas	49.7	32.7	9.5	.....	.....	4.6	2.5	.....	1.0
30	Königsberg retort gas	49.0	36.5	5.6	.....	.....	6.8	1.1	.....	1.0
31	† Gloucester retort gas, bit. coal	48.88	38.25	4.64	.....	.....	4.95	.03	.51	2.74
32	Dresden retort gas	48.7	33.4	8.0	.....	.....	3.0	1.5	1.4	4.0
33	Retort coal gas, average	48.49	35.9	6.61	.....	.....	3.83	.12	.....	5.05
34	Retort coal gas, Sexton	48.32	39.55	4.63	.....	.....	5.18	.....	.....	2.32
35	† Redhill retort gas, bit. coal	48.18	39.41	3.41	.....	.....	4.40	.74	.49	3.37
36	Coal gas, Bates	48.1	36.5	.60	4.3	.....	.....	.30	.40	9.8
37	‡ Good Solvay average coke oven gas	48.0	35.5	5.1	4.2	1.2	.....	1.3	.5	4.2
38	Retort coal gas	48.0	39.5	7.5	.....	.....	3.8	.....	.....	1.2
39	London retort gas	48.0	37.6	3.7	.....	.....	4.4	.....	.3	6.0
40	† London retort gas, bit. coal	47.99	37.64	3.75	.....	.....	4.41	.....	.26	5.95
41	Common coal gas	47.9	33.3	6.0	12.3	.....	.....	.....	.5	
42	Common coal gas	47.73	35.6	6.15	4.88	.....	.....	1.41	.31	3.92
43	Boston, Mass., retort coal gas	47.29	38.67	1.04	.....	.....	5.21	1.04	.....	6.75
44	Coke oven, Milwaukee	47.1	34.7	6.2	3.8	.....	.....	3.1	.3	4.8
45	Average retort coal, Klumpp	47.0	36.0	8.0	.....	.....	.5–4.3	1.6	.4	2.7–6.5
46	Newcastle, Staffordshire	46.31	39.01	3.74	.....	.....	4.53	.08	.11	6.22
47	Hannover retort gas	46.3	37.5	11.2	.....	.....	3.2	.8	.....	1.0
48	Hannover, Ger., retort coal gas	46.27	37.55	.81	.....	.....	3.17	.81	.....	11.39
49	Lean coke oven, Klumpp	46.2	27.1	6.2	.....	.....	2.5	3.0	.6	14.4
50	Heidelberg retort coal gas	46.2	34.02	8.88	.....	.....	5.09	3.01	.65	2.15
51	Retort coal gas, Wyer	46.0	40.0	6.0	5.0	.....	.....	.5	.5	2.0
52	London coal retort gas, Chandler	46.0	39.5	7.5	.....	.....	3.8	.....	.....	3.2
53	Common coal gas	46.0	39.5	7.5	3.8	.....	.....	.6	.1	2.5
54	Cincinnati, Ohio, retort coal gas	45.85	39.26	.82	.....	.....	5.17	.82	.....	8.08
55	Manchester retort gas	45.6	34.9	6.6	.....	.....	6.5	3.7	.....	2.7
56	Coal retort gas— Bunsen & Roscoc	45.58	34.9	6.64	.....	.....	6.46	3.67	.....	2.75
57	† Nottingham retort gas, bit. coal	45.52	39.66	5.63	.....	.....	5.63	.81	.24	2.51
58	Retort coal gas, Lewes, 9–11 O in coal	45.45	36.42	9.86	4.44	1.04	.....	2.79		
59	† Bristol retort gas, bit. coal	44.57	40.7	4.77	.....	.....	4.58	.....	.27	5.11
60	Common coal gas	44.4	37.1	5.2	2.3	.....	.....	1.3	1.1	8.6
61	† Preston retort gas, cannel	43.95	39.33	4.64	.....	.....	6.22	.84	.25	4.77
62	Coal gas (16 c.p.)	43.5	35.0	11.5	.....	.....	5.5	2.0	.5	2.0
63	† Ipswitch retort gas, bit. coal	43.26	38.73	2.46	.....	.....	4.53	.06	.12	10.84

TABLE LXIII—*Concluded*

COMPOSITION OF COKE OVEN AND RETORT COAL GAS

No.	Description.	Volumetric Analysis.								
		H_2.	CH_4.	CO.	C_2H_2.	C_6H_6.	Heavy Hydro-carbons.	CO_2.	O_2.	Remainder and N_2.
64	† Sheffield retort gas, cannel	43.05	43.05	4.72	.....	.....	6.28	.24	.10	2.56
65	Retort coal gas, Lewes, 11–12 O in coal	42.26	37.14	11.93	4.76	.88	.....	3.13		
66	Average coke oven, Klumpp	42.0	34.3	6.0	.....	.....	4.0	2.5	1.1	10.1
67	Coal retort gas, Humpedge	41.72	41.88	4.98	.....	.....	8.72	.....	.....	2.70
68	Otto coke oven, poor part of gas	41.6	29.6	6.3	.....	.....	2.8	3.2	.4	16.1
69	† Birmingham retort gas, bit. coal	40.23	39.	4.05	.....	.....	4.76	1.50	.36	10.1
70	† Leeds retort gas, cannel	40.23	42.74	5.02	.....	.....	7.28	.34	.07	4.32
71	Birmingham, Eng., retort coal gas	40.23	39.0	1.50	.....	.....	4.76	1.50	.....	13.01
72	Bonn retort gas	39.8	43.1	4.7	.....	.....	4.7	3.0	.....	4.7
73	Common coal gas	39.78	45.16	7.04	6.38	.....	.....	1.08	.06	.50
74	Glasgow, Scot., retort coal gas	39.18	40.26	.29	.....	.....	10.0	.29	.....	9.98
75	† Glasgow retort gas, cannel	39.18	40.26	7.14	.....	.....	10.0	.29	.06	3.07
76	Retort gas, Wright, 1½ hrs	38.33	44.03	5.68	.....	.....	5.98	2.09	.....	3.89
77	Otto coke oven, good part of gas	37.6	40.8	5.6	.....	.....	5.8	3.7	.4	6.1
78	Rich coke oven, Klumpp	37.4	40.4	7.1	.....	.....	5.8	2.1	1.6	5.6
79	† St. Andrews retort gas, cannel	36.63	42.13	5.16	.....	.....	10.04	2.73	.48	2.83
80	† Liverpool retort gas, cannel	36.44	44.28	3.39	.....	.....	7.90	1.70	.19	6.10
81	Liverpool, Eng., retort coal gas	36.44	44.28	1.70	.....	.....	7.90	1.70	.....	7.98
82	Retort gas cannel coal, Sexton	36.1	37.8	6.8	.....	.....	16.4	.....	.....	2.9
83	Cleveland, Ohio, retort coal gas	34.8	28.8	.20	.....	.....	11.2	.20	.....	24.8
84	Hoffman coke oven, Bates	33.32	36.31	6.49	2.04	.....	.....	1.41	.43	20.0
85	† Manchester retort gas, cannel	33.24	42.93	6.61	.....	.....	12.23	.35	1.0	3.64
86	Cannel-coal gas	27.7	50.0	6.8	13.0	.....	.....	.10	.....	2.4
87	Wigan cannel coal retort gas, Henry, 5th hour	21.3	56.0	11.0	.....	.....	7.0	.....	.....	4.7
88	Newcastle coal, 10 minutes	20.1	57.38	6.19	.....	.....	10.62	2.21	.....	3.50
89	Wigan cannel coal, retort gas, Henry, 1st hour	16.0	58.0	12.3	.....	.....	12.0	.....	.....	1.7

90	Wigan cannel coal retort gas, Henry, 1st hour	8.8	72.0	1.9	.....	.....	12.0	.....	.....	5.3
91	Wigan cannel coal retort gas, Henry, 1st hour	0	82.5	3.2	.....	.....	13.0	.....	.....	1.3
	Low volatile coal:									
92	Solvay oven, Blauvelt, 1st hr.	42.1	31.6	4.6	6.0	.50	.....	.10	.80	14.3
93	" " 2d hr.	51.6	32.8	4.3	3.6	.70	.....	.10	.80	6.1
94	" " 3d hr.	46.8	33.2	4.9	3.8	1.10	.....	.10	.70	9.4
95	" " 4th hr.	49.6	33.5	4.6	3.3	.90	.....	.10	1.10	6.9
96	" " 5th hr.	50.8	33.1	4.6	3.7	.80	.....	.10	.80	6.1
97	" " 7th hr.	44.4	30.1	4.4	2.5	.70	.....	.20	1.0	16.7
98	" " 8th hr.	46.2	32.6	4.5	2.9	.50	.....	.20	.90	12.2
99	" " 10th hr.	47.4	29.1	4.1	1.6	.40	.....	0	.90	16.5
100	" " 12th hr.	53.6	29.5	4.6	1.2	.50	.....	.10	.60	9.9
101	" " 14th hr.	69.2	17.0	4.4	.6	.20	.....	.10	.90	7.6
102	" " 15th hr.	44.0	3.0	2.9	3.5	.30	.....	0	4.9	41.4
	High volatile coal:									
103	Solvay oven, Blauvelt, 1st hr.	41.4	41.5	5.8	3.2	.90	.....	.90	.50	5.8
104	" " 2d hr.	43.8	40.4	5.1	2.6	1.0	.....	.90	.40	5.8
105	" " 3d hr.	47.2	37.6	4.9	2.1	1.0	.....	.90	.70	5.6
106	" " 4th hr.	48.6	36.2	5.0	2.1	1.1	.....	1.1	.40	5.5
107	" " 5th hr.	49.5	33.3	4.6	1.7	1.0	.....	.80	1.0	8.1
108	" " 6th hr.	49.8	31.4	4.6	1.6	.90	.....	1.1	1.1	9.5
109	" " 7th hr.	47.6	31.0	4.4	1.3	.90	.....	2.2	1.6	11.0
110	" " 8th hr.	54.2	31.5	4.8	1.5	1.0	.....	.90	.50	5.6
111	" " 10th hr.	55.3	29.1	4.9	2.0	.50	.....	1.0	.60	6.6
112	" " 12th hr.	64.8	23.1	5.3	.3	.10	.....	.60	.40	5.4
113	" " 14th hr.	67.0	18.2	5.3	.4	0	.....	.50	.60	8.0
114	" " 16th hr.	69.4	13.6	6.2	0	0	.....	.2	.4	10.2

Table LXIV

COMPOSITION OF UNITED STATES COKE

(Mainly from U. S. Geological Survey Reports)

Origin.	Moisture.	Volatile.	Fixed Carbon.	Ash.	Sulphur.
From Connelsville bituminous coal, 72 hours roasting.	.23	1.32	88.18	10.27	.81
From Connelsville bituminous coal, 48 hours roasting.	.19	.51	89.6	9.7	.63
Foundry Ganley Mountain, U.S.Geological Survey. . .	.75	.35	86.38	12.52	.70
Foundry Milwaukee Solvay, U.S.G.S.	.27	.48	89.63	9.62	.79
From Connelsville, U.S.G.S.	.18	.32	88.75	10.75	.87
From Alabama coal, U.S.G.S. No. 1	.33	.72	82.63	16.32	.69
From Arkansas coal, U.S.G.S. No. 6	1.30	2.85	78.84	17.01	1.46
From Illinois coal, U.S.G.S. No. 2	1.57	2.83	75.42	20.18	2.75
From Illinois coal, U.S.G.S. No. 3	.96	.44	87.08	11.52	1.19
From Indiana coal, U.S.G.S. No. 1	1.16	1.24	84.81	13.19	1.77
From Indian Territory, U.S.G.S. No. 2	2.60	1.85	80.25	15.30	1.58
From Iowa, U.S.G.S. No. 1	2.11	1.79	77.01	19.09	4.25
From Iowa, U.S.G.S. No. 3	1.80	1.95	78.64	17.61	4.76
From Kentucky, U.S.G.S. No. 1	.51	.84	93.25	5.40	.87
From Kentucky, U.S.G.S. No. 4	.52	.73	86.40	12.35	2.37
From Missouri, U.S.G.S. No. 2	2.18	1.82	81.34	14.66	2.82
From West Virginia, U.S.G.S. No. 1	.40	1.95	87.47	.18	.71
From West Virginia, U.S.G.S. No. 2	.59	1.31	86.70	11.40	2.24
From West Virginia, U.S.G.S. No. 3	.38	.87	84.48	14.27	1.19
From West Virginia, U.S.G.S. No. 4	.20	1.15	85.42	13.23	.69
From West Virginia, U.S.G.S. No. 5	.42	.43	84.34	14.81	.83
From West Virginia, U.S.G.S. No. 6	1.00	1.85	89.60	7.55	.70
From West Virginia, U.S.G.S. No. 10	.60	.55	90.34	8.51	.58
From West Virginia, U.S.G.S. No. 12	1.00	.75	90.37	7.88	1.05
Connelsville average of 3, J. B. Proctor	....	....	88.96	9.74	.81
Chattanooga, Tenn., average of 4, J. B. Proctor	....	....	80.51	16.34	1.59
Birmingham, Ala., average of 4, J. B. Proctor	....	....	87.29	10.54	1.19
Pocahontas, Va., average of 3, J. B. Proctor	....	....	92.53	5.74	.60
New River, W. Va., average of 8, J. B. Proctor	....	....	92.38	7.21	.56
Big Stone Gap, Ky., average of 7, J. B. Proctor	....	....	93.23	5.69	.75
Alabama, run-of-mine, foundry, Moldenke	1.34	1.03	83.35	14.28	1.3
Alabama washed slack, foundry, Moldenke	.75	.75	86.00	11.50	.9
Colorado washed slack, foundry, Moldenke	.44	1.31	82.18	16.07	.44
Illinois washed slack, foundry, Moldenke	2.78	.74	83.35	13.13	2.49
Pennsylvania washed slack, foundry, Moldenke	.23	.29	92.53	6.95	.81
Pennsylvania washed slack, foundry, Moldenke	.91	2.26	80.84	15.99	1.87
Tennessee, foundry, Moldenke	.22	.11	92.44	7.23	.61
Tennessee, foundry, Moldenke	1.67	1.6	76.87	19.86	2.45
Virginia, foundry, Moldenke	.16	.80	93.24	5.80	.42
Virginia, foundry, Moldenke	1.52	1.67	88.52	8.29	1.02
West Virginia, foundry, Moldenke	.67	.46	95.47	4.00	.53
West Virginia, foundry, Moldneke	.60	2.35	84.09	12.96	2.26
Proposed standard foundry coke specification	.5	.75	89.75	9.0	.7

TABLE LXV

PRODUCTS OF BITUMINOUS GAS COAL DISTILLATION (JÜPTNER)

(Variation with coal composition)

Coal from		Pas De Calais.		England.	Commentry	Blanzy.
Coal composition, per cent by weight	Moisture	2.17	2.70	3.31	4.34	6.17
	Ash	9.04	7.06	7.21	8.80	10.73
	O_2	5.56	6.66	7.71	10.10	11.70
	H_2	5.06	5.36	5.40	5.53	5.64
	C	88.38	86.97	85.89	83.37	81.66
	N_2	1	1	1	1	1
Products of distillation, per cent by weight	Gas	13.70	15.08	15.81	16.95	17.00
	Tar	3.90	4.65	5.08	5.48	5.59
	Ammonia water	4.59	5.57	6.80	8.61	9.86
	Coke	71.48	57.63	64.90	60.88	58.00
	Coal dust	6.33	7.07	7.41	8.08	9.36
Gas produced per kg coal	Vol. cubic meter	30.13	31.01	30.64	29.73	27.44
Volumetric analysis of gas	CO_2	1.47	1.58	1.72	2.79	3.13
	CO	6.68	7.17	8.81	9.86	11.93
	H_2	54.21	52.79	50.10	45.45	42.26
	CH_4	34.37	34.43	35.03	36.42	37.14
	C_6H_6	.79	.99	.96	1.04	.88
	C_2H_4	2.48	3.02	3.98	4.44	4.76

TABLE LXVI

AVERAGE DISTILLATION PRODUCTS OF CRUDE MINERAL OILS (ROBINSON)

Class.	Name of Product.	Average Per Cent Yield.	Specific Gr. 60° F.	Bé.	Boiling-Point, F.	
Petroleum ether	Cymogene	small	.590	107	32	American Oil
	Rhigolene	.1	.625–.631	94–92	64	
	Gasolene	1 –1.5	.635–.658	91–83	86–158	
Petroleum spirit	*C* naphtha (benzene)	10	.680–.700	76–70	140–212	
	B naphtha	2 – 2.5	.717–.72	65	175–250	
	A naphtha (benzene)	2– 2.5	.742–.745	58	212–265	
Lamp kerosene	Water white	12 –20	.780–.785	49	300–575	
	Ordinary kerosene	40 –55	.800–.810	44	300–700	
Intermediate	Gas oil	....	.85	35		
Heavy oils	Lubricating oil	17.5	.885–.920	28–22		
	Paraffine	2	.980	13		
	Residue and loss	5 –10				
Petrol	Gasolene or benzene	5 –16	.725–.765	63–53		Russian Oil
Lamp oils	Kerosene	30 –40	.817–.828	41–39		
Intermediate	Solar oil	10 –12	.840–.860	37–33		
Lubricating oils	Spindle oil	12 –15	.870–.897	31–26		
	Engine oil	25 –40	.908–.912	24		
	Cylinder oil	3 –5	.915–.920	23–22		
Fuel oil	Residue, astatki or gondron	10 –15	.900–.950	25–17		

TABLE LXVII

FRACTIONATION TESTS OF KEROSENES AND PETROLEUMS

No.	Class and Density of Original.	Volumetric Per Cent Distilled.	Temperature of Distillation. Deg. F. at Beginning.	Temperature of Distillation. Deg. F. at End.	Specific Gravity of Distillate, 60° F.	Density, Baumé.
1	American kerosene Robinson Sp.gr. .797 Bé. 45.67	23	257	302	.748	57.21
		11	302	347	.767	52.5
		8	347	392	.783	49.0
		9	392	437	.794	46.5
		10	437	482	.807	43.5
		16	482	527	.821	40.8
		7	527	572	.831	38.8
		3	572	680	.836	37.5
		Left as res. 13	680	....	.843	36.5
2	Russian kerosene Robinson Sp.gr. .825 Bé. 39.9	9	239	284	.786	48.2
		18	284	329	.799	45.4
		20	329	374	.816	41.6
		13	374	419	.829	38.9
		18	419	464	.831	38.5
		12	464	509	.845	36.8
		6	509	554	.857	33.5
		1	554	680	.864	32.2
		Left as res. 3	680	....	.877	29.8
3	American kerosene Robinson Sp.gr.	25	293	338		
		23	338	383		
		28	383	428		
		13	428	473		
		7	473	518		
		3	518	572		
4	Alsatian petroleum Engler & Schestopal Sp.gr. .801 Bé. 44.8	.08	....	302		
		30.35	302	392		
		44.7	392	482		
		20.2	482	572		
		3.8	572	608		
5	"Kaiser" oil Engler & Schestopal Sp.gr. .795 Bé. 46.1	29.7	302	392		
		32.3	392	482		
		26.3	482	572		
		11.7	572	608		
6	Pennsylvania kerosene Maschinenfabrik, Augsburg Sp.gr. .800 Bé. 45	15.8	....	302		
		22	302	392		
		19.25	392	482		
		16.8	482	572		
		26.15	572	608		

TABLE LXVII—*Continued*

FRACTIONATION TESTS OF KEROSENES AND PETROLEUMS

No.	Class and Density of Original.	Volumetric Per Cent Distilled.	Temperature of Distillation.		Specific Gravity of Distillate, 60° F.	Density, Baumé.
			Deg. F. at Beginning.	Deg. F. at End.		
7	German, benzol Maschinenfabrik, Augsburg Sp.gr. .873 Bé. 30.5	68 28.7	.... 212 302	212 302		
8	Beaumont, Texas Richardson & Wallace Sp.gr. .912 Bé. 23.5	2.5 40.0 20.0 25.0	230 302 572 752	302 572 752	.8749 .9089 .9182	30.1 24.2 23.6
9	Ohio Mabey & Noble Sp.gr. .829 Bé. 38.9	23.0 21.0 21.0 27.0	185 302 572 752	302 572 752	.7297 .8014 .8404 .8643	62.3 45.1 36.8 32.2
10	Pennsylvania Sp.gr. .914 Bé. 23.2	21.0 41.0 14.0 23.0	176 302 572 752	302 572 752	.7188 .7984 .8334 Paraffine	65.2 45.8 38.3
11	Virginia, petroleum, heavy B. Redwood Sp.gr. at 32° F. .873, Bé. 30.5	1.0 1.3 12.0	.... 212 284	212 284 356		
12	Virginia, petroleum, light B. Redwood Sp.gr. 32° F. .8412 Bé. 36.6	1.3 4.3 11.0 17.7 25.2 28.5	.... 212 248 284 320 356	212 248 284 320 356 392		
13	Pennsylvania, light B. Redwood Sp.gr. at 32° F. .816 Bé. 41.6	4.3 10.7 16.0 23.7 28.7 31.0	.... 212 248 284 320 356	212 248 284 320 356 392		
14	Penn., heavy, B. Redwood Sp.gr. at 32° F. .886. Bé.	.... 12.0	 500	500 536		
15	Java, petroleum B. Redwood Sp.gr. at 32° F. .923 Bé. 21.8	1.0 1.0 .... 7.7 15.0 22.3 24.3	.... 212 248 320 356 392 428	212 248 320 356 392 428 464		

Table LXVIII

FRACTIONATION TESTS OF GASOLENES

No.	Class and Density of Original.	Volumetric Per Cent Distilled.	Temp. of Distillation. Deg. F. at Beginning.	Deg. F. at End.	Density of Distillate, 60° F.	Density, Baumé.
1	Gasolene [Blount]	39	158	212	.722	63.9
	Sp.gr. .739	49	212	248	.748	57.2
	Bé. 59.5	7.5	248	271	.757	55.0
		3.5	271	....	.767	52.6
2	Gasolene [Blount]	48	158	212	.727	62.5
	Sp.gr. .736	37	212	248	.747	57.5
	Bé. 60.2	11.5	248	271	.762	53.9
		2.5	271	....	.767	52.6
3	Gasolene [Blount]	65.5	149	212	.708	67.9
	Sp.gr. .717	26.5	212	248	.742	58.8
	Bé. 65.3	4.5	248	271	.754	55.8
		2.5	271	....	.769	52.2
4	Gasolene [Blount]	69.0	149	212	.707	68
	Sp.gr. .716	22.0	212	248	.743	58.5
	Bé. 65.5	4.5	248	271	.751	56.5
		3	271	....	.770	51.9
5	Gasolene [Blount]	65.0	145	212	.704	68.9
	Sp.gr. .716	26.0	212	248	.742	58.9
	Bé. 65.5	5.0	248	271	.753	56
		2.5	271	....	.772	51.5
6	Gasolene [Blount]	70.0	149	212	.71	67.2
	Sp.gr. .717	24.0	212	248	.744	58.2
	Bé. 65.3	3.0	248	271	.753	55.9
		1.5	271	....	.769	52
7	Gasolene [Blount]	67.0	140	212	.706	68.2
	Sp.gr. .719	21.0	212	248	.742	58.9
	Bé. 64.7	6.0	248	271	.750	56.8
		4.5	271	....	.770	51.9
8	Gasolene [Blount]	66	140	212	.700	70
	Sp.gr. .711	24	212	248	.731	61.6
	Bé. 66.9	6.5	248	271	.741	58.9
		2.5	271	....	.762	53.8
9	Gasolene [Blount]	59	145	212	.701	69.8
	Sp.gr. .715	28.5	212	248	.736	60.2
	Bé. 65.8	7.0	248	271	.750	56.6
		4.0	271	....	.765	53.0
10	Gasolene [Blount]	62.0	145	212	.699	70.1
	Sp.gr. .712	25.0	212	248	.730	61.8
	Bé. 66.7	7.0	248	271	.742	58.8
		5.0	271	....	.758	54.8
11	Gasolene [Blount]	68	136	212	.699	70.1
	Sp.gr. .710	22.5	212	248	.736	60.2
	Bé. 67.2	6.5	248	271	.750	56.6
		2.0	271	....	.736	60.2

TABLE LXVIII—*Continued*

FRACTIONATION TESTS OF GASOLENES

No.	Class and Density of Original.	Volumetric Per Cent Distilled.	Temp. of Distillation. Deg. F. at Beginning.	Temp. of Distillation. Deg. F. at End.	Density of Distillate, 60° F.	Density, Baumé.
12	Gasolene [Blount] Sp.gr. .700 Bé. 70	86.5	133	212	.692	72.3
		11.5	212	248	.739	59.5
		....	248	271		
		.5	271			
13	Gasolene [Blount] Sp.gr. .718 Bé. 65	59	145	212	704	69
		29	212	248	.742	58.8
		8	248	271	.755	55.5
		3	271	....	.768	52.5
14	Gasolene [Blount] Sp.gr. .717 Bé. 65.3	64	149	212	.705	68.8
		26	212	248	.740	59.4
		6.5	248	271	.754	55.8
		2.5	271	....	.770	51.7
15	Gasolene [Blount] Sp.gr. .717 Bé. 65.3	68	149	212	.705	68.8
		23	212	248	.743	58.6
		5.5	248	271	.755	55.5
		2.5	271	....	.773	51.2
16	Gasolene [Blount] Sp.gr. .717 Bé. 65.3	67.5	143	212	.706	68
		22	212	248	.742	58.8
		5.5	248	271	.758	54.9
		3.5	271	....	.770	51.8
17	Gasolene [Blount] Sp.gr. .715 Bé. 65.8	58	136	212	.700	70
		24	212	248	.733	61
		9.5	248	271	.749	57
		6.5	271	....	.770	51.8
18	Gasolene [Blount] Sp.gr. .705 Bé. 68.6	73	131	212	.697	71
		17.5	212	248	.736	60.2
		5	248	271	.751	56.5
		3	271	....	.768	52.5
19	Gasolene [Blount] Sp.gr. .705 Bé. 68.6	74	140	212	.696	71.1
		15.5	212	248	.736	60.3
		5.0	248	271	.745	57.9
		4.0	271	....	.764	53.2
20	Gasolene [Chambers] Sp.gr. .71 Bé. 67.18	6.67	148.8	149.2		
		6.66	149.2	167.0		
		6.67	167.0	176.0		
		6.67	176	176		
		6.66	176	186.8		
		6.67	186.8	197.6		
		6.67	197.6	206.6		
		6.66	206.6	212.0		
		6.67	212.0	219.2		
		6.67	219.2	226.4		
		6.66	226.4	233.6		
		6.67	233.6	248.0		
		7.67	248.0	258.8		
		5.66	258.8	284.0		
		4.37	284.0	311		

TABLE LXIX

COMPOSITION OF BLAST-FURNACE GAS AND AIR GAS

No.	Description.	Volumetric Analysis. CO	H_2	CH_4	CO_2	N_2	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$
1	Brymbo-Derby	34.0	1.3	......	5.7	59.0	5.97	.86
2	Coke in small Dowson producer, Dowson and Larter	32.6	1.0	......	1.4	65.0	23.2	.96
3	Westphalia, Allen	30.7	3.3	.5	7.8	57.7	3.94	.8
4	Blast-furnace, splint coal, Sexton No. 3	30.1	6.2	3.2	5.4	55.1	5.58	.85
5	Durham coke, blast furnace, max. CO_2 content in one month	30.1	2.9	......	7.1	59.9	4.24	.81
6	Durham coke, blast furnace, min. CO_2 content in one month	29.7	.9	......	10.3	59.1	2.88	.74
7	Blast furnace, Upper Silesia, Germany	29.7	6.3	......	7.8	56.2	3.81	.79
8	Blast furnace, charcoal, Ebelmann	29.6	......	......	5.9	63.4	5.01	.83
9	Metallurgical air gas, Lewes	29.0	2.5	......	4.0	64.5	7.25	.88
10	Blast furnace, Westphalia, Germany, dry	29.0	4.0	......	10.0	57.0	2.9	.74
11	Blast furnace, coke, Ebelmann	28.61	2.74	.20	11.39	57.06	2.52	.72
12	Coke, Lackawanna Steel Co	28.4	1.7	......	11.8	......	2.40	.71
13	Blast furnace, unwashed, Sexton	28.19	10.24	1.78	6.23	53.56	4.53	.82
14	Blast furnace, unwashed, Sexton	28.09	7.11	2.77	7.92	54.14	3.55	.78
15	Blast furnace, splint coal, Sexton No. 2	28.06	5.45	4.39	8.61	53.38	3.26	.76
16	Blast furnace, English	27.71	1.34	......	8.62	62.33	3.21	.76
17	Blast furnace, Minette District, Germany	27.5	3.0	.54	10.0	54.5 +5.0	2.75	.73
18	Blast-furnace gas	27.5	3.0	......	10.0	59.4	2.75	.73
19	Blast-furnace coal, Archibald	27.5	3.68	3.62	6.15	59.27	4.47	.82
20	Bituminous coke air gas, Loomis Pettibone	27.3	5.1	.8	2.7	......	10.1	.91
21	Blast furnace, splint coal, Sexton No. 1	27.15	5.48	4.29	8.57	54.29	3.16	.76
22	Blast furnace, Cleveland, Eng., Robinson	27.1	1.3	......	12.4	59.2	2.18	.69
23	Blast furnace, Glengarmock, washed, Robinson	27.0	2.0	5.0	6.0	60.0	4.5	.82
24	Blast furnace, Frodingham coke, Allen	26.9	2.4	......	6.3	64.4	4.27	.80
25	Coke, Lackawanna Steel Co	26.9	3.0	......	12.0	......	2.24	.69
26	Coke, Lackawanna Steel Co	26.8	1.4	......	8.6	......	3.12	.76
27	Coke, Lackawanna Steel Co	26.6	2.4	......	12.0	......	2.22	.69
28	Blast-furnace, splint coal, Sexton No. 4	26.4	12.23	1.71	6.79	58.81	3.89	.80
29	Blast furnace, Westphalia, Germany, 10 per cent H_2O	26.1	3.6	......	9.0	51.3 +10.0	2.90	.74
30	Coke, Lackawanna Steel Co	26.1	2.0	......	12.1	......	2.15	.68
31	Scotch blast furnace, Wishan	25.83	4.55	3.45	7.21	58.96	3.58	.78

TABLE LXIX—*Continued*

COMPOSITION OF BLAST-FURNACE GAS AND AIR GAS

No.	Description.	Volumetric Analysis. CO	H_2	CH_4	CO_2	N_2	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$
32	Isabella Furnace, U. S. Steel Co., Gayley	25.8	4.25	......	12.6	57.35	2.04	.67
33	Producer gas, little steam	25.3	9.2	3.1	3.4	58.2	7.44	.88
34	Dowson gas, average	25.0	18.0	3.0	7.0	47	3.57	.78
35	Blast furnace, Glengarmock, unwashed, Robinson	25.0	7.0	4.0	7.0	57.0	3.57	.78
36	Producer gas, little steam	24.8	8.5	5.2	5.6	55.1	4.44	.82
37	Blast furnace, Wishan, Pellew	24.75	2.33	.75	5.75	66.42	4.30	.81
38	Blast furnace charcoal, Ebelmann	24.65	5.19	.93	12.01	57.22	2.05	.67
39	Producer gas, little steam	24.0	9.8	3.4	6.0	55.6	4.0	.80
40	Blast furnace, Lediebas, Germany, (coke) dry	24.0	2.0	2.0	12.0	6.0	2.0	.67
41	Blast-furnace coke	24.0	2.0	2.0	12.0	60.0	2.0	.67
42	Durham coke, Allen	23.84	2.34	......	10.94	water 5.55 57.3	21.8	.69
43	Isabella Furnace, U. S. Steel Co., Gayley	23.2	......	......	16	......	1.45	.59
44	Blast furnace, Upper Silesia, Germany	23.0	......	......	6.0	59.0 +12.0	3.83	.79
45	Producer gas, little steam	22.74	8.37	2.56	5.3	60.13	4.29	.80
46	Producer gas, little steam	22.1	6.8	3.74	4.84	61.68	4.57	.82
47	Blast furnace, Lediebas, Germany, coke, 10 per cent H_2O	21.6	1.8	1.8	10.8	54.0 +10.0	2.0	.67
48	Producer gas, little steam	20.8	6.9	2.2	4.6	64.9	4.53	.82
49	Isabella Furnace, U. S. Steel Co., Gayley	20.6	......	......	13.0	......	1.58	.61
50	Producer gas, little steam	20.0	5.3	3.0	3.6	67.5	5.56	.85
51	Loomis Pettibone coal	20.0	14.0	2.0	8.2	55.5	2.44	.71
52	Loomis Pettibone wood	20.0	14.0	2.0	16.0	47.7	1.25	.55
53	Anthracite before making water gas	17.8	......	......	9.7	72.5	1.84	.65
54	Taylor gas, average	12.0	21.0	2.0	5	57.0	2.4	.71
55	Mond gas	12.0	29.0	2.0	14.5	42.5	.83	.45
56	Mond gas	11.5	28.5	2.1	15	42.9	.77	.43

Table LXX

RATE OF FORMATION OF CO FROM CO_2 AND CARBON

Form of Carbon.	Temp. Deg. F.	Time, Seconds.	Volumetric Analysis.				Authority.
			CO_2	CO	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$	
Fine, amorphous.....	1472	480	13.6	86.4	6.43	.864	Boudouard
Charcoal, 2–5 mm.....	1472	480	39.9	60.1	1.51	.601	
Charcoal, hazel nut...	1472	480	17.1	82.9	4.88	.829	
Coke, 2–5 mm........	1472	480	79.1	20.9	.26	.209	
Coke, hazel nut......	1472	480	83.6	16.4	.20	.164	
Gas carbon, 2–5 mm..	1472	480	80.1	19.9	.25	.199	
Gas coke, hazel nut...	1472	480	86.7	13.3	.15	.133	
1. Charcoal, 5 mm....	1472	189	49.7	50.3	1.01	.503	Clement
	1472	116	49.6	50.4	1.01	.504	
	1472	57	48.2	51.8	1.07	.518	
	1472	46	47.8	52.2	1.09	.522	
	1472	24	62.5	37.5	.60	.375	
	1472	16	71.7	28.3	.40	.283	
	1472	12	75.5	24.5	.32	.245	
	1472	2.7	93.7	6.3	.067	.063	
	1472	1.6	96.1	3.9	.041	.039	
2. Charcoal, 5 mm....	1562	123	25.7	74.3	2.88	.743	Clement
	1562	54	29.8	70.2	2.36	.702	
	1562	24	42.8	57.2	1.34	.572	
	1562	13	47.4	52.6	1.11	.526	
	1562	9.3	70.3	29.7	.42	.297	
	1562	4.6	70.3	29.7	.42	.297	
	1562	3.7	77.6	22.4	.29	.224	
	1562	3.3	77.5	22.5	.29	.225	
3. Charcoal, 5 mm....	1652	64	12.7	87.3	6.87	.873	Clement
	1652	44	13.3	86.7	6.52	.867	
	1652	10	29.2	70.8	2.42	.708	
	1652	4.3	50.2	49.8	.99	.498	
	1652	2.8	68.9	31.1	.45	.311	
	1652	2.2	65.6	34.4	.52	.344	
4. Charcoal, 5 mm.. .	1697	119	5.3	94.7	17.9	.947	Clement
	1697	81	6.7	93.3	13.9	.933	
	1697	12	15.2	84.8	5.57	.848	
	1697	5.8	28.2	71.8	2.54	.718	
	1697	4.3	35.8	64.2	1.79	.642	
	1697	2.3	62.5	37.5	.60	.375	
5. Charcoal, 5 mm.. .	1832	70	5.1	94.9	18.6	.949	Clement
	1832	18.6	5.7	94.3	16.5	.943	
	1832	8.2	9.7	90.3	9.3	.903	
	1832	3.7	20.3	79.7	3.92	.797	
	1832	2.3	20.5	79.5	3.88	.795	
Charcoal, 5 mm......	2012	36.5	1.3	98.7	75.9	.987	Clement
	2012	10.4	1.7	98.3	57.8	.983	
	2012	4.97	1.9	98.1	51.6	.981	
	2012	3.6	2.7	97.3	36.0	.973	
	2012	1.9	5.4	94.6	17.5	.946	
6. Coke............	1652	142	72.4	27.6	.382	.276	Clement
	1652	80	86.9	13.1	.151	.131	
	1652	44	90.6	9.4	.104	.094	
	1652	25	94.3	5.7	.061	.057	

Table LXX—*Continued*

RATE OF FORMATION OF CO FROM CO_2 AND CARBON

Form of Carbon.	Temp. Deg. F.	Time, Seconds.	Volumetric Analysis.				Authority.
			CO_2	CO	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$	
6. Coke	1652	16	95.1	4.9	.051	.049	Clement
	1652	9.6	97.4	2.6	.027	.026	
	1652	3.7	99.2	.8	.008	.008	
7. Coke	1832	123	21.6	78.4	3.62	.784	Clement
	1832	80	35.6	64.4	1.81	.644	
	1832	33	47.1	52.9	1.12	.529	
	1832	19	68.0	32.0	.47	.320	
	1832	6.4	86.1	13.9	.16	.139	
	1832	4.1	88.5	11.5	.13	.115	
	1832	3.1	90.8	9.2	.101	.092	
	1832	2.0	93.7	6.3	.067	.063	
8. Coke	2012	90	2.9	97.1	33.6	.971	Clement
	2012	30	14.6	85.4	5.85	.854	
	2012	13	33.9	66.1	1.95	.661	
	2012	6.7	44.4	55.6	1.25	.556	
	2012	3.2	68.3	31.7	.46	.317	
	2012	1.8	69.6	30.4	.437	.304	
	2012	1.7	76.0	24.0	.316	.240	
	2012	1.6	77.9	22.1	.284	.221	
	2012	1.5	78.6	21.4	.272	.214	
	2012	.96	86.7	13.3	.154	.133	
9. Coke	2192	19	1.1	98.9	89.7	.989	Clement
	2192	13	2.2	97.8	44.4	.978	
	2192	8.3	4.7	95.3	20.2	.953	
	2192	2.4	31.5	68.5	2.18	.685	
	2192	1.6	56.1	43.9	.78	.439	
	2192	1.1	66.5	33.5	.504	.335	
Coke	2372	8.9	.1	99.9	999	.999	Clement
	2372	4.1	2.1	97.9	46.5	.979	
	2372	2.1	6.8	93.2	13.7	.932	
	2372	1.1	16.6	83.4	5.02	.834	
10. Anthracite	2012	34	12.2	87.8	7.2	.878	Clement
	2012	9.4	39.9	60.1	1.5	.601	
	2012	5.4	52.3	47.7	.91	.477	
	2012	3.3	69.8	30.2	.43	.302	
	2012	2.4	73.5	26.5	.36	.265	
11. Anthracite	2192	47	.3	99.7	332.3	.997	Clement
	2192	10	14.4	85.6	5.95	.856	
	2192	5.1	28.5	71.5	2.5	.715	
	2192	2.8	57.7	42.3	.73	.423	
	2192	1.6	69.0	31.0	.45	.310	
12. Anthracite	2372	12.4	.1	99.9	999	.999	Clement
	2372	6.0	3.5	96.5	27.6	.965	
	2372	3.6	17.6	82.4	4.68	.824	
	2372	3.0	19.1	80.9	4.23	.809	
	2372	1.91	33.7	66.3	1.97	.663	
	2372	1.07	49.7	50.3	1.01	.503	

Table LXXI

COMPOSITION OF PRODUCER GAS

No.	Description.	Volumetric Analysis.							Ratios	
		CO.	H_2.	CH_4.	Heavy Hydro car-bons.	CO_2.	O_2.	Re-mainder and N_2.	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$
1	Bit., half water and half air gas, down draft	34.7	26.8	1.80	0.30	3.60	0.20	32.6	9.64	.907
2	Charcoal gas, Thwaite	34.1	0.20	...	...	0.80	...	64.9	42.6	.978
3	Charcoal gas, Thwaite	33.8	0.10	...	...	1.30	...	64.8	26.0	.964
4	Charcoal, Loomis Pettibone, down draft	31.4	9.30	1.90	...	1.20	0.20	56.0	26.2	.963
5	From sawdust in Switzerland	29.8	6.50	6.90	.30	6.00	...	50.5	4.97	.833
6	Producer gas, little steam	28.8	13.47	.10	...	6.20	.20	51.23	4.65	.824
7	From anthracite coal, little steam	28.0	4.00	4.00	...	4.00	...	60.00	7.00	.875
8	Producer gas, little steam	27.8	13.33	...	...	6.20	.40	52.27	4.49	.818
9	Anthracite, Koerting,up draft	27.8	13.33	...	...	6.20	.40	52.27	4.49	.818
10	Producer gas, Jones	27.6	15.30	1.	4	3.90	...	51.80	7.08	.876
11	Producer gas, Monaco	27.5	16.67	...	...	8.40	.90	46.53	3.28	.766
12	Peat gas, Akermann	27.2	.90	3.10	...	12.10	...	56.7	2.25	.692
13	Ebelmann producer	27.2	14.0	...	...	5.50	...	53.3	4.95	.826
14	Ingham producer, Sexton	27.0	10.90	1.28	...	4.50	...	56.32	6.00	.857
15	Anthracite, up draft, less than ¼ load	27.00	13.90	...	...	4.00	.20	54.90	6.75	.873
16	From bituminous coal, American	26.97	13.00	.33	...	4.37	.21	55.12	6.17	.86
17	Bit., Loomis Pettibone, down draft	26.90	9.40	1.10	.30	3.60	.20	58.5	7.47	.882
18	Wilson producer, Sexton	26.89	11.55	1.45	...	4.00	...	56.11	6.72	.870
19	Bit. coal, up draft, Duff	26.80	13.40	4.40	...	4.40	...	51.00	6.10	.859
20	Wilson producer, bit. coal, England, Patterson and Stead	26.80	11.50	1.40	...	4.00	...	56.30	6.70	.870
21	Anthracite, Koerting, up draft	26.80	13.47	.10	...	6.20	.20	53.23	4.32	.812
22	Produesr gas, Jones	26.50	17.50	2.	1	4.40	...	49.50	6.02	.854
23	Siemans closed hearth, steam blast, Sexton	26.40	12.13	2.00	...	9.16	...	50.31	2.88	.744
24	Producer gas	26.30	13.60	.40	...	4.80	.20	54.70	5.49	.846
25	Anthracite, Taylor, up draft	26.10	15.00	.20	...	5.30	.20	53.2	4.92	.831

26	Producer gas	26.10	15.00	.20	...	5.30	.20	53.2	4.92	.831
27	Siemans closed hearth	26.00	1.90	.71	...	4.20	...	67.19	6.19	.860
28	Bit. coal, up draft	26.00	13.00	4.	00	4.00	...	53.00	6.50	.867
29	Anthracite, Koerting, up draft	26.00	14.40	.20	...	6.00	1.20	52.2	4.33	.811
30	Producer gas	26.00	14.40	.20	...	6.00	1.20	52.2	4.33	.811
31	Producer gas	25.70	15.30	.20	...	5.50	.40	52.9	4.67	.825
32	Anthracite, Taylor, up draft	25.70	13.30	.20	...	5.50	.40	54.9	4.67	.824
33	Bit. and Anth., up draft, Smith, load $\frac{1}{4}$ to $1\frac{1}{4}$	25.60	22.90	...	...	4.80	.20	46.5	5.35	.842
34	Siemans open hearth, Snelus	25.60	...	4.40	...	4.30	...	65.7	5.95	.856
35	Coke fuel, Adams, whole test	25.5	12.0	.40	...	5.30	.65	56.15	4.81	.828
36	Producer gas, Witz	25.4	16.5	1.	00	4.80	1.20	51.10	5.29	.842
37	Producer gas, little steam	25.3	9.2	3.10	.80	3.40	...	58.20	7.43	.883
38	Bit. coal, up draft	25.3	9.2	3.10	.80	3.40	...	58.20	7.43	.883
39	Coke fuel, last six hours	25.3	13.2	.35	...	5.40	.60	55.15	4.70	.824
40	Anthracite, up draft, Dowson	25.25	18.50	2.00	...	5.25	...	49.00	4.85	.829
41	Anth., English, Dowson, Lewes	25.17	18.90	1.40	...	5.98	...	48.55	4.20	.808
42	Dowson producer gas, Thorpe	25.07	18.73	.62	...	6.57	...	49.01	3.82	.792
43	Dowson producer, Anthracite, Eng., Foster	25.07	18.73	.31	.31	6.57	.03	48.98	3.82	.792
44	From anthracite	25.07	18.73	.31	.31	6.57	...	49.01	3.82	.792
45	Anthracite pea, English, Lewes	25.00	14.00	1.00	...	6.00	...	54.00	4.17	.806
46	From anth., American, Wyer	25.00	20.00	...	...	5.00	.50	49.50	5.00	.833
47	Producer gas, little steam	24.80	8.50	5.20	.40	5.60	.40	55.10	4.43	.816
48	Bit., Loomis Pettibone, down draft	24.80	8.50	1.00	.10	4.10	.10	61.40	6.06	.859
49	From Illinois coal	24.50	17.80	3.60	3.20	3.70	.40	46.80	6.62	.869
50	From bit. coal, American	24.47	11.79	.30	...	3.96	.18	59.30	6.18	.860
51	From bit. coal	24.40	8.60	2.40	...	5.20	...	59.40	4.69	.824
52	Siemans closed hearth, steam blast, Snelus	24.40	8.60	2.40	...	5.20	...	59.40	4.69	.824
53	Bituminous and anthracite coal, down draft, Loomis Pettibone	24.40	14.43	3.01	.20	8.80	.50	48.66	2.77	.735
54	Anth., up draft, Deutz Mathot	24.30	18.90	.57	...	6.60	.30	49.33	3.68	.786
55	Bit. coal, reversible, Thwaite Allen	24.00	3.30	...	...	5.00	...	67.70	4.80	.828
56	Producer gas, little steam	24.00	9.80	3.40	.40	6.00	.80	55.60	4.00	.800
57	From German lignite	23.99	10.64	.25	...	5.21	.63	59.28	4.60	.821
58	Producer gas, Jones	23.80	19.80	1.	30	6.30	...	48.80	3.77	.792
59	$\frac{3}{4}$ caking, $\frac{1}{4}$ non-caking French coal, Sexton	23.70	8.00	2.20	...	4.10	.40	61.60	5.79	.854
60	Wilson producer gas, Sexton	23.66	10.55	3.05	...	5.25	...	59.49	4.51	.820
61	Producer gas	23.60	12.14	.10	...	5.60	3.00	55.56	4.21	.808
62	Anth. coal, up draft, less than $\frac{1}{4}$ load, Smith	23.50	12.00	....	...	5.00	2.00	57.50	4.70	.825

TABLE LXXI — *Continued*

COMPOSITION OF PRODUCER GAS

No.	Description.	Volumetric Analysis.							Ratios	
		CO.	H_2.	CH_4.	Heavy Hydro carbons.	CO_2.	O_2.	Remainder and N_2.	$\frac{CO}{CO_2}$.	$\frac{CO}{CO+CO_2}$.
63	Ingham producer, Sexton	23.41	13.00	2.22	...	4.69	...	56.68	5.00	.834
64	Wilson producer, Sexton	23.41	13.82	2.22	...	4.69	...	55.86	5.00	.834
65	Wilson producer, Sexton	23.11	14.81	1.14	...	4.84	...	56.10	4.78	.827
66	From bit. coal, American, Wyer	23.00	10.00	3.00	.50	5.00	.50	58.00	4.60	.822
67	Producer gas, Uppenborn	23.00	17.00	2.	00	6.00	...	52.00	3.83	.794
68	Anthracite coal, load $\frac{1}{4}$ to $1\frac{1}{4}$, Smith	23.00	22.60	...	...	4.00	1.00	49.40	5.75	.852
69	Anthracite coal, load $\frac{1}{4}$ to $1\frac{1}{4}$, Smith	23.00	23.50	...	...	7.00	2.00	44.50	3.28	.767
70	Producer gas	23.00	14.14	...	...	7.60	.20	55.06	3.02	.752
71	Bit., down draft, Loomis Pettibone	22.80	10.13	2.20	...	5.60	.40	58.87	4.07	.865
72	Producer gas	22.80	17.53	...	...	7.80	.20	51.67	2.92	.745
73	Producer gas, little steam	22.74	8.37	2.56	.36	5.30	.54	60.13	4.29	.809
74	Producer gas	22.70	16.57	...	...	7.80	...	52.93	2.91	.744
75	Producer gas	22.70	15.10	...	...	7.80	.20	54.20	2.91	.744
76	Bituminous coal	22.6	7.80	1.50	...	4.40	...	63.7	5.15	.838
77	Producer gas, Langer	22.5	24.00	...	...	7.50	...	46.0	3.00	.750
78	Anth., Loomis Pettibone, down draft	22.3	11.30	.70	...	5.50	.20	60.00	4.05	.802
79	Producer gas, little steam	22.10	6.80	3.74	.34	4.84	.40	61.78	4.57	.821
80	Producer gas	22.00	15.87	...	...	7.60	.20	54.33	2.89	.744
81	Anthracite, up draft, load $\frac{1}{4}$ to $1\frac{1}{4}$, Smith	22.00	21.30	...	...	5.00	1.00	50.70	4.40	.815
82	From bituminous coal	22.00	10.50	2.60	.60	5.70	.40	58.20	3.86	.794
83	Producer gas	21.90	16.80	...	...	8.40	.30	52.60	2.61	.724
84	Ebelmann producer	21.83	7.64	...	...	9.06	...	61.47	2.41	.709
85	Producer gas	21.70	16.04	...	...	8.80	.20	53.26	2.47	.711
86	Siemans closed hearth	21.60	9.60	3.60	...	5.00	...	60.20	4.32	.812
87	Gas from bituminous coal after heating in open-hearth furnace regenerator, Darby	21.60	17.70	2.00	.40	10.50	...	47.80	2.06	.673

88	Anthracite pea, English, Lewes	21.00	15.20	1.20	...	8.20	.20	54.20	2.56	.719
89	Anthracite, up draft, load $\frac{1}{4}$ to $1\frac{1}{4}$, Smith	21.00	21.50	...	...	9.00	1.00	47.50	2.33	.700
90	Bit., down draft, Loomis Pettibone	21.00	9.50	1.90	...	6.50	.60	60.50	3.23	.764
91	North Dakota, No. 2, U.S.G.S.	20.90	14.33	4.85	...	8.69	.23	51.00	2.402	.708
92	Producer gas, little steam	20.80	6.90	2.20	.20	4.60	.40	64.90	4.52	.819
93	Producer gas	20.50	13.00	...	...	9.80	.30	56.40	2.09	.678
94	Ingham producer, Sexton	20.40	12.60	3.50	...	5.50	...	58.00	3.70	.788
95	Anthracite coal, up draft, less than $\frac{1}{4}$ load, Smith	20.30	17.00	...	...	8.00	.70	54.00	2.54	.719
96	From lignite	20.20	25.00	...	...	6.60	2.20	46.00	3.06	.754
97	Dowson producer, anth. coal, last 6 hrs., Adams	20.13	15.64	1.16	...	6.09	.74	56.24	3.30	.766
98	Producer gas, little steam	20.00	5.30	3.00	.20	3.60	.40	67.50	5.55	.848
99	Indian Territory No. 1, U.S.G.S.	19.39	7.69	4.92	...	8.25	.11	59.64	2.35	.700
100	Dowson producer, anth. coal, average for whole test, Adams	19.05	15.59	1.31	...	5.93	.79	57.33	3.22	.764
101	Montana No. 1, U.S.G.S.	18.67	8.00	4.84	...	9.04	.36	59.09	2.065	.674
102	Bit. and anth., down draft, Sandberg	18.40	9.90	1.10	.10	5.10	...	65.40	3.61	.784
103	Lignite, Smith	18.30	25.60	...	...	8.40	1.80	45.90	2.18	.685
104	Texas No. 2, U.S.G.S.	18.22	9.63	4.81	...	9.60	.20	57.54	1.90	.654
105	Indian Territory, No. 4, U.S.G.S.	17.64	10.43	6.30	...	7.29	.23	58.11	2.42	.708
106	Colorado No. 1, U.S.G.S.	17.38	11.05	5.00	...	10.11	.55	55.91	1.715	.631
107	Bituminous coal, reversible, Thwaite, Lewes	17.16	7.33	4.	10	11.83	...	59.58	1.45	.593
108	Alabama No. 2, U.S.G.S.	16.65	7.20	5.64	...	8.16	.10	62.25	2.04	.670
109	From anthracite	16.60	24.20	2.00	...	11.30	...	45.90	1.47	.595
110	Siemans closed hearth, steam blast, Sexton	16.15	19.43	2.66	...	11.53	...	50.23	1.40	.584
111	West Virginia No. 4, U.S.G.S	15.82	11.16	3.74	...	10.16	.24	58.88	1.56	.610
112	Lignite	15.50	27.0	...	...	8.00	.35	46.00	1.94	.660
113	Wyoming No. 2, U.S.G.S.	15.46	10.79	5.52	...	10.21	.59	57.43	1.51	1.51
114	Illinois No. 3, U.S.G.S.	15.31	8.35	4.46	...	10.53	.15	61.20	1.455	.593
115	Illinois No. 4, U.S.G.S.	15.12	9.98	6.00	...	9.72	.12	59.06	1.558	.608
116	West Virginia No. 9, U.S.G.S.	14.77	9.51	6.65	...	8.90	.33	59.84	1.66	.623
117	Texas No. 1, U.S.G.S.	14.43	10.54	7.48	...	11.10	.22	56.23	1.302	.567
118	West Virginia No. 1, U.S.G.S.	14.34	2.81	5.56	...	10.50	.10	66.69	1.362	.577
119	West Virginia No. 12, U.S.G.S.	14.21	12.98	4.61	...	10.34	.12	57.74	1.372	.580
120	Indiana No. 1, U.S.G.S.	14.10	9.56	6.08	...	9.89	.25	60.12	1.427	.589
121	Lignite, Loomis Pettibone, down draft	14.10	13.80	2.60	.40	10.60	.30	58.20	1.33	.571
122	West Virginia No. 9, U.S.G.S.	13.70	9.55	6.60	...	10.40	.20	59.55	1.319	.569
123	Bituminous, Mond, Lewes	13.20	24.80	2.30	...	12.90	...	46.80	1.030	.506
124	From bituminous coal	13.20	24.80	2.30	...	12.90	...	46.80	1.030	.506

TABLE LXXI—*Concluded*

COMPOSITION OF PRODUCER GAS

No.	Description.	Volumetric Analysis. CO.	H_2.	CH_4.	Heavy Hydro carbons.	CO_2.	O_2.	Remainder and N_2	Ratios $\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$
125	West Virginia No. 7, U.S.G.S.	12.75	10.308	6.758	...	9.617	.084	60.483	1.323	.571
126	Iowa No. 2, U.S.G.S.	12.571	9.529	7.671	...	10.057	.171	60.001	1.25	.554
127	Kentucky No. 3, U.S.G.S.	12.45	10.92	6.52	...	10.87	.29	58.95	1.148	.535
128	Kansas No. 5, U.S.G.S.	12.40	9.05	7.417	...	10.267	.133	60.733	1.21	.547
129	West Virginia No. 8, U.S.G.S.	11.927	9.454	6.4	...	10.327	.218	61.674	1.153	.537
130	Indiana No. 2, U.S.G.S.	11.46	10.60	6.10	...	11.80	.070	59.97	.970	.493
131	Bituminous, up draft, excess steam, Mond, Humphrey	11.00	29.00	2.00	...	16.00	...	42.0	.687	.408
132	Bituminous, up draft, excess steam, Duff	11.00	28.00	2.50	...	15.50	...	43.0	.710	.415
133	Bit. coal, Mond gas, Sexton	11.00	27.20	1.80	.40	17.10	...	42.5	.644	.392
134	From bit. coal, much steam	11.00	27.50	2.00	...	16.50	...	43.00	.666	.4
135	Coke and breeze, Mond, Allen	10.80	25.20	.40	...	16.80	...	46.80	.643	.391
136	Missouri No. 2, U.S.G.S.	10.53	7.63	6.33	...	12.07	.20	63.24	.873	.465
137	From bit. coal (much steam), Darby	10.50	24.80	2.60	.70	17.80	...	43.60	.590	.371
138	Siemans closed hearth, excess steam to make NH_3	10.00	23.00	3.00	...	15.00	...	49.00	.666	.400
139	German brown coal lignite	8.10	24.30	16.50	1.40	17.00	3.10	29.60	.475	.323
140	From coke, German, Meyer, 1st hr.	26.60	6.80	1.30	...	6.50	.10	58.70	4.09	.804
141	" " " 2d hr.	28.20	5.90	2.70	...	4.80	...	58.40	5.87	.854
142	" " " 3d hr.	27.80	6.40	2.60	...	4.20	...	59.00	6.62	.868
143	" " " 4th hr.	26.70	8.80	1.80	...	4.70	.10	57.90	5.68	.851
144	" " " 5th hr.	26.60	9.10	2.20	...	5.00	...	57.10	5.32	.843
145	" " " 6th hr.	29.00	8.00	1.70	...	4.00	...	57.30	7.25	.878
146	" " " 7th hr.	28.40	5.80	2.00	...	4.80	.20	58.80	5.92	.856
147	" " " 8th hr.	27.80	5.10	1.60	...	4.60	.10	60.80	6.05	.858
148	Mond producer, bit. coal, Bone & Wheeler, air blast, sat. H_2O at 60°	27.30	16.60	3.35	...	5.25	...	47.50	5.20	.838
149	" " " " " " 65°	25.40	18.30	3.40	...	6.95	...	45.95	3.66	.874

Table LXXII

COMPOSITION OF WATER GAS

No.	Description.	Volumetric Analysis.						Ratios.	
		H_2.	CO.	CH_4.	CO_2.	O_2.	N_2.	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$
1	Essen water gas, coke, Sexton......	54.52	31.86	1.62	12.00		0		
2	Dellurck process water gas, Lewes No. 3........................	52.76	37.50	..	4.08	.46	5.2	9.2	.90
3	Strong water gas, Moore..........	52.76	35.88	4.11	2.05	..	4.33	17.5	.95
4	Dellurck Process water gas, Lewes No. 1........................	52.43	38.30	..	4.73	.74	3.80	8.1	.89
5	Average water gas, Lewes.........	51.89	40.08	.10	4.80	..	3.13	8.35	.89
6	From anthracite before carburetting for illumination, O'Connor......	51.8	43.4	..	3.5	..	1.3	12.4	.93
7	Dellurck Process water gas, Lewes No. 2........................	50.09	39.95	..	5.38	1.22	3.36	7.4	.88
8	Blue water gas, Morehead.........	50.0	43.25	.5	3.0	..	3.25	14.4	.935
9	Water gas, Allen.................	49.65	42.89	.75	2.97	..	3.74	14.4	.935
10	Uncarburetted water gas..........	49.55	45.89	..	3.87	..	.71	11.8	.92
11	Uncarburetted water gas	49.50	35.93	1.05	4.25	..	8.75	8.45	.89
12	Essen water gas, coke, Thorpe.....	49.17	43.75	.31	2.71	..	4.00	16.1	.94
13	Water gas before carburetting, Lowell........................	48.6	43.2	2.0	3.0	.4	2.8	14.4	.93
14	Average water gas, Lewes.........	48.31	35.93	1.05	4.25	.51	9.95	8.45	.89
15	Water gas before carburetting, average.....................	47.97	42.75	4.23	2.80	.05	2.2	15.3	.94
16	Water gas before carburetting, average.....................	45.57	44.85	4.41	4.45	.5	.77	10.1	.91
17	Lowe water gas, anthracite, Thorpe.	44.50	42.10	..	3.60	..	9.80	11.7	.92
18	Water gas, anthracite, Loomis Pettibone.......................	44.3	42.4	2.7	3.5	.2	6.9	12.1	.92
19	Water gas, bituminous coke, Loomis Pettibone....................	42.1	32.6	2.9	5.3	.3	16.8	6.15	.86

Table LXXIII

COMPOSITION OF OIL PRODUCER GAS

Name.	Volumetric Analysis, Per Cent.							Ratio.		B.T.U. per Cubic Foot.	
	CO	H_2	CH_4	C_nH_{2n}	O_2	CO_2	N_2	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$	High.	Low.
Process of International Amet. Co.	8.0	12.0	16.2	2.0	.2	4.2	57.4	1.9	.66	275	249
Do..............	8.6	10.0	7.0	4.2	.3	5.4	64.4	1.6	.61	209	192
Do..............	7.8	9.8	6.0	4.0	.4	6.5	65.5	1.2	.55	192	176
Lowe process.....	7.3	47.4	28.6	10.0	.2	2.0	4.5	3.7	.78	661	605
" "	8.35	53.65	22.50	5.4	.4	2.25	7.45	3.7	.79	543	487
" "	6.0	46.0	26.0	10.30	.3	3.0	8.4	2.0	.67	630	566

Table LXXIV

GAS PRODUCER TESTS

U.S.G.S.—(Fernald)

COAL AND GAS ANALYSIS

Coal.	Proximate Analysis of Coal.				B.T.U. per Pound Dry Coal.	B.T.U. in Gas per Pound Dry Coal.	Eff. of Producer Process.	Gas Analysis by Volumes.						Ratio, $\frac{CO}{CO_2}$	Ratio, $\frac{CO}{CO+CO_2}$	Tar.
	Moisture.	Volatile.	Fixed C.	Ash.				CO	H_2	CH_4 and Others	CO_2	O_2	Diff. and N			
Brown lignite, North Dakota, No. 2	39.56	27.78	26.30	6.36	11255	7830	63	20.90	14.33	4.85	8.69	.23	51.02	2.40	.7063	50 gals. 13,800 lbs. coal
Bit. semi-caking, Indian Territory, No. 1	5.00	36.51	49.98	8.51	13455	8620	64	19.39	7.69	4.69	8.25	.11	59.65	2.35	.7007	$2\frac{1}{2}$ bbls. 11,200 lbs. coal
Bit. clinker, Montana, No. 1	11.40	34.55	43.31	10.74	11934	6580	55	18.67	8.00	4.84	9.04	.36	59.10	2.05	.6730	10,200 lbs. coal
Brown lignite, Texas, No. 2	33.71	29.25	29.76	7.28	11086	8060	73	18.22	9.63	4.81	9.60	.20	57.53	1.90	.6549	60 gals. 9,050 lbs. coal
Bit. Indian Territory, No. 4	9.0	33.96	40.68	16.36	11392	9980	88	17.64	10.43	6.30	7.29	.23	58.11	2.30	.7075	50 gals. 6,300 lbs. coal
Black lignite, clinker slight, Colorado, No. 1	20.24	32.26	41.65	5.85	12245	7860	64	17.38	11.05	5.00	10.11	.55	55.90	1.72	.6322	50 gals. yellow 10,933 lbs. coal
Hard bit. non-caking, Alabama, No. 2	3.76	33.45	53.29	9.50	13365	9000	73	16.65	7.20	5.64	8.16	.10	62.24	2.05	.6711	Considerable, not measured
Semi-caking bit., West Virginia, No. 4	1.99	28.89	60.30	8.82	14202	11610	82	15.82	11.06	3.74	10.16	.24	58.88	1.56	.6080	2,100 lbs. coal
Bit. non-caking, Wyoming, No. 2	9.44	35.02	34.82	26.72	10656	6168	58	15.46	10.79	5.52	10.21	.59	57.43	1.52	.6022	60 gals. 12,100 lbs. coal
Bit. non-caking, no clinker, Illinois, No. 3	7.62	30.87	51.78	9.73	13041	8330	64	15.31	8.35	4.46	10.53	.15	61.19	1.46	.5924	60 gals. 10,500 lbs. coal
Bit. non-caking, no clinker, Illinois, No. 4	12.43	32.65	45.70	9.22	12834	8840	69	15.12	9.98	6.00	9.72	.12	59.06	1.56	.6086	75 gals. 10,500 lbs. coal

West Virginia, No. 9....	2.22	31.05	59.83	6.90	14548	11380	78	14.77	9.51	6.65	8.90	.33	59.85	1.66	.6239	50 gals. 6,000 lbs. coal
Brown lignite clinker, Texas, No. 1.........	33.50	32.34	23.80	10.36	10928	7260	66	14.33	10.59	7.48	11.10	.22	56.22	1.29	.5635	150 gals. 12,800 lbs. coal
West Virginia, No. 1....	1.61	36.85	55.40	6.14	14396	9260	64	14.34	2.81	5.56	10.50	.10	66.69	1.36	.5772..	6,900 lbs. coal
West Virginia, No. 12...	1.43	18.93	73.19	6.45	14825	10150	68	14.21	12.98	4.61	10.34	.12	57.75	1.38	.5788	50 gals. 8,100 lbs. coal
Bit. non-caking, Indiana, No. 1...............	11.51	36.04	42.37	10.08	13037	7730	60	14.10	9.56	6.08	9.89	.25	60.13	1.43	.5877	70 gals.black 11,700 lbs. coal
West Virginia, No. 9....	2.66	32.00	59.61	5.73	14580	8150	56	13.70	9.55	6.60	10.40	.20	59.55	1.32	.5684	120 gals. 1,300 lbs. coal
West Virginia, No. 7....	2.99	21.19	69.15	6.67	14720	13140	89	12.75	10.31	6.76	9.62	.08	60.48	1.32	.5699..	6;000 lbs. coal
Bit., Iowa, No. 2.......	16.69	31.42	31.19	20.70	10489	9300	88	12.57	9.53	7.67	10.06	.17	60.00	1.19	.5554	50 gals. 4,833 lbs. coal
Bit. semi-caking, Kentucky, No. 3.........	7.28	38.57	45.16	8.99	13226	8610	65	12.45	10.92	6.52	10.87	.29	58.95	1.15	.5338	100 gals. black 11,100 lbs. coal
Kansas, No. 5..........	4.35	31.97	52.43	11.25	13421	10500	79	12.40	9.05	7.42	10.27	.13	60.73	1.20	.5469..	4,000 lbs. coal
West Virginia, No. 8....	2.66	32.58	59.00	5.76	14558	9070	62	11.93	9.45	6.40	10.33	.22	60.67	1.16	.5359	75 gals. 8,900 lbs. coal
Bit. non-caking, Indiana, No. 2...............	8.72	39.60	41.95	9.73	12953	10140	79	11.46	10.60	6.10	11.80	.07	59.97	.98	.4926	60 gals. 6,900 lbs. coal
Bit., Missouri, No. 2....	11.60	35.28	38.28	14.84	11882	8820	74	10.53	7.63	6.33	12.07	.20	63.23	.87	.4659..	3,300 lbs. coal

Table LXXV
COMPOSITION OF POWDERED COAL, PRODUCER GAS

Sample.	Volumetric Analysis, Per Cent.							Ratio.		B.T.U. per Cubic Foot.	
	CO	H_2	CH_4	C_nH_{2n}	O_2	CO_2	N_2	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$	High.	Low.
1	15.85	6.17	4.09	....	1.4	9.2	63.29	1.7	.63	119	111
2	13.52	11.51	5.17	....	.3	8.1	61.40	1.7	.63	140	129
3	12.20	10.50	3.20	....	.0	7.6	66.50	1.6	.62	112	103
4	18.2	12.20	2.1	.1	.1	4.9	62.40	3.7	.79	128	119
5	13.8	10.4	2.5	.5	....	8.0	64.80	1.7	.63	118	109

Table LXXVI
COMPOSITION OF BOILER FLUE GASES—(Volumetric)

Average of.	Stat. Boiler, Illinois Coal, U. S. Geological Survey.					Locomotive Boiler, U. S. Geological Survey.				
	Analysis.			$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$	Analysis.			$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$
	CO_2	O_2	CO			CO_2	O_2	CO		
4	3.4	17.5	0	0	0	10.16	8.49	.13	.0128	.0126
3	3.7	17.2	0	0	0	11.10	7.84	.23	.0207	.0203
5	4.4	16.3	0	0	0	11.15	7.52	.20	.0179	.0176
5	5.0	15.0	0	0	0	11.45	6.92	.00	0	0
5	5.3	14.7	.1	.0189	.0185	11.46	7.49	.10	.00875	.00865
5	5.9	14.4	.04	.0068	.00674	11.50	7.08	.17	.0148	.0147
6	6.2	14.1	.03	.00485	.00482	11.96	7.00	.23	.0193	.0189
9	6.4	13.7	.07	.0109	.0108	11.96	7.07	.14	.0117	.0155
16	6.6	13.0	.10	.0152	.0149	12.05	6.93	.15	.0125	.0123
9	6.8	12.6	.01	.00147	.0147	12.20	6.94	.05	.0041	.0407
14	7.0	12.8	.06	.0086	.0085	12.45	5.87	.22	.0177	.0174
20	7.2	12.6	.08	.0111	.011	13.57	4.49	.20	.0147	.0145
18	7.4	12.4	.00	0	0	13.87	4.75	.25	.018	.0177
20	7.6	12.9	.05	.0066	.00655					
14	7.8	12.1	.03	.00385	.00375					
30	8.0	11.7	.04	.005	.00498					
31	8.2	11.6	.10	.0122	.012					
27	8.4	11.3	.10	.0119	.01175					
16	8.6	11.1	.10	.0116	.0115					
17	8.8	10.8	.20	.0228	.0222					
19	9.0	10.7	.10	.0111	.011					
14	9.2	10.4	.10	.0109	.01075					
16	9.4	10.1	.20	.0213	.0208					
10	9.6	9.9	.20	.0208	.0204					
8	9.8	9.4	.20	.0204	.02					
8	10.0	9.2	.20	.020	.0196					
6	10.2	9.9	.20	.0196	.0192					
8	10.4	8.9	.5	.048	.046					
4	10.8	8.6	.02	.00185	.00185					
3	11.0	8.8	.36	.0327	.0317					
2	11.1	8.6	.30	.027	.0253					
1	11.4	7.9	.40	.035	.034					

Table LXXVII

CALORIFIC PROPERTIES OF BEST AIR-GAS MIXTURES—(Low Values)

(All at 32° F. and 29.92" Hg.)

Name of Gas.	Volumetric Analysis, Per Cent.									Air.		Gas.		Gas B.T.U.		Mixture B.T.U.	
	CO	H_2	CH_4	C_2H_4	C_2H_6	C_6H_6	O_2	CO_2	N_2	Cu.ft. per Cu.ft. Gas.	Lbs. per Lb. of Gas.	Lbs. per per Cu.ft.	Cu.ft. per Pound.	Per Pound.	Per Cu.ft. 32° F. 29.92" Hg.	Per Pound.	Per Cu.ft. 32° F 29.92" Hg.
Carbon monoxide..	100	...	...	...	...	..	..	...	...	2.39	2.470	.07807	12.8090	4369	341	1258.6	100.59
Hydrogen........	...	100	...	...	..	..	..	...	...	2.39	34.32	.005621	177.9093	51892	292	1469	86.1
Methane.........	...	...	100	...	..	..	..	...	...	9.56	17.244	.0447	22.349	21463	959	1176.4	90.81
Ethylene.........	...	...	...	100	..	..	..	...	...	14.34	14.557	.07951	12.578	20053	1595	1931.7	103.97
Ethane..........	...	...	...	...	100	..	..	...	...	16.73	16.115	.08379	11.9354	20481	1716	1196.6	96.78
Benzene.........	...	...	...	...	..	100	..	...	...	35.85	13.194	.2193	4.56	17305	3795	1219.17	102.98
Retort coal gas....	8.6	52.5	31.35	1.1	..	1.1	.03	1.5	3.5	5.0084	12.683	.031872	31.375	17022.7	542.6	1244.1	90.30
Coke-oven gas, rich	7.1	37.4	40.4	2.9	..	2.9	1.6	2.1	5.6	6.381	11.753	.04382	22.8206	15452.9	677.1	1211.7	91.74
Coke-oven gas, lean	6.2	46.2	27.1	1.3	..	1.2	.6	3	14.4	4.4597	9.300	.038705	25.8364	12458.4	482.2	1209.5	88.32
Coke-oven, gas, average..........	6.0	42	34.3	2.0	..	2.0	1.1	2.5	10.1	5.4301	10.872	.04031	24.807	14384	579.84	1211.6	90.1
Oil gas (retort)....	1.0	18.5	52.5	11.7	..	11.8	.5	.5	...	11.3936	14.943	.06153	16.25	19443	1196.5	1219.5	96.52
Carburetted water gas...........	28.1	21.8	30.7	12.9	..	..	.5	3.8	2.2	5.9774	8.9395	.05397	18.5288	12888	659.6	1296.6	94.53
Blast-furnace gas..	27.5	3.0	...	...	..	..	..	10.0	59.5	.7289	.7309	.08049	12.4239	1273.8	102.53	735.9	59.30
Water gas........	35.93	49.5	1.05	...	..	..	..	4.25	9.27	2.1458	3.964	.04368	22.89377	6344	277.13	1278	88.09
Anthracite producer gas......	25.7	15.3	.2	...	..	..	.4	5.5	52.9	.9989	1.1586	.069536	14.381	1928.9	134.13	893.6	67.102
Bituminous producer gas (up)...	14.34	2.81	5.56	...	..	..	.10	10.50	66.69	.9374	1.059	.079021	12.654	1397.4	110.43	680	59.15
Do. (down).......	20.0	14.0	2.0	.2	..	..	.1	8.2	55.5	1.023	1.162	.07105	14.074	1849.9	131.45	855.6	64.98
Do. mond........	12	29	2.0	...	..	..	..	14.5	42.5	1.1711	1.4961	.063169	15.83022	2292	144.78	918.2	66.67
Lignite producer gas...........	20.90	14.33	4.85	...	..	..	.23	8.69	51.02	1.3056	1.5036	.070101	14.265	2276.9	159.62	909.4	69.23
Alcohol..........	...	...	...	...	..	..	..	...	...	14.424	9.06	.01285	7.782	12100.4	1554.9	1202.8	100.8
Gasolene.........	...	...	...	...	..	..	..	...	...	52.74	15.24	.2793	3.58	20519.7	5731.7	1263.5	106.66
Kerosene.........	...	...	...	...	..	..	..	...	...	88.71	15.079	.4748	2.106	20255	9617.7	1259.7	107.2
Natural gas, Kans.	.25	...	98.2	...	..	.1	.25	...	...	9.3969	17.004	.0446	22.42	21301	950.1	1183.1	91.38

Heating value of gases based on experimental value of constituents.

TABLE LXXVIII

LIMITS OF PROPORTION FOR EXPLOSIVE AIR-GAS MIXTURES

Gas.	Per Cent of Gas in the Mixture by Volume.			Authority.
	Combining Proportion.	When Air is in Excess.	When Gas is in Excess.	
Carbon monoxide	29.6	16.5	74.95	Eitner
" "	29.6	16.5	58.4	Bunte
" "	29.6	13.0	75	Clowes
Hydrogen	29.6	9.45	66.4	Eitner
"	29.6	9.45	54.4	Bunte
"	29.6	7.69	33.3	M.I.T.
"	29.6	5.00	72.0	Clowes
Water gas, theoretical	29.6	12.4	66.75	Eitner
" "	29.6	12.4	54.3	Bunte
" actual	....	9.0	55.0	Clowes
" "	....	3.8	16.7	M.I.T.
" "	....	8.33	33.3	M.I.T.
Coal gas	14.9	7.9	19	Eitner
"	14.9	7.9	11.2	Bunte
"	14.9	5.3	16.7	Clerk
"	14.9	6.0	29	Clowes
"	....	6.7	20	Clerk
"	....	6.25	14.28	Grover
Boston illuminating gas	....	6.67	25.0	M.I.T.
" "	....	6.25	12.5	M.I.T.
" "	....	6.67	20.0	M.I.T.
Acetylene	7.9	3.35	52.3	Eitner
"	7.9	3.35	49.0	Bunte
"	7.9	1.54	47.6	M.I.T.
"	7.9	2.96	66.7	
"	7.9	3.0	82.0	Clowes
Ethylene	6.5	4.1	14.6	Eitner
"	6.5	4.1	10.5	Bunte
Methane	9.5	6.1	12.8	Eitner
"	9.5	6.1	9.7	Bunte
"	9.5	5.0	13.0	Clowes
Ether	3.4	2.75	7.7	Eitner
"	3.4	2.75	5.0	Bunte
Benzene	2.7	2.65	6.5	Eitner
"	....	2.65	3.9	Bunte
"	....	2.4	4.9	Eitner
Pentane	2.6	2.4	2.5	Bunte
"	2.6	2.4	4.9	Eitner
Gasolene	....	2.5	2.4	Bunte
" 86° Bé	....	1.54	4.76	M.I.T.
" 71° Bé	....	1.54	4.76	M.I.T.
" 65° Bé	....	1.31	4.76	M.I.T.
Alcohol	6.5	3.95	13.65	Eitner
"	6.5	3.95	9.7	Bunte
Blau oil gas	....	4.0	8.0	Hallock
Pintsch oil gas	9.0	5.0	13.0	Lucke
Ethane	....	4.0	22.0	Clowes

Table LXXIX

RATE OF COMBUSTION OF COAL

U. S. Geological Survey Tests

Coal.	Proximate Coal Analysis.				Draft, Inches, H_2O.		Pounds per Square Foot per Hour.		
	Moisture.	Volatile.	Fixed C.	Ash.	Hood.	Furnace.	As Fired.	Dry.	Combustible.
Alabama No. 1	2.56	31.00	52.52	13.92	.36	.18	20.68	20.72	17.38
" No. 1, briquettes	2.63	33.00	50.96	13.41	.46	.18	19.48	18.97	16.40
" No. 2	4.83	32.98	48.65	13.54	.39	.17	22.60	21.54	18.60
Arkansas No. 1	1.99	18.61	66.36	13.04	.36	.12	17.30	16.90	14.80
" No. 1, briquettes	.94	21.21	67.65	10.20	.35	.15	18.93	18.74	16.63
" No. 2	1.07	16.86	73.65	8.42	.35	.15	16.00	15.70	14.38
" No. 2, briquettes	4.88	22.49	60.30	12.33	.37	.15	18.18	17.31	14.95
" No. 3	1.97	16.04	72.74	9.25	.40	.16	20.50	19.68	17.15
" No. 3, briquettes	2.60	17.35	62.04	18.01	.60	.22	21.00	20.49	16.80
" No. 4, briquettes	3.85	14.06	71.98	10.11	.45	.19	20.15	19.41	16.50
" No. 5	2.22	12.54	73.68	11.56	.53	.28	21.87	21.42	16.60
Colorado No. 1, lignite	19.78	35.85	39.00	5.37	.66	.33	22.15	17.80	15.22
Illinois No. 1	9.69	36.91	38.21	15.19	.40	.18	27.60	24.90	20.50
" No. 2, washed	10.45	37.77	41.72	10.06	.42	.15	24.95	22.36	20.05
" No. 3	8.51	31.19	48.75	11.55	.58	.21	23.20	21.23	17.90
" No. 4	13.47	33.48	41.59	11.46	.55	.16	23.00	19.84	17.00
" No. 4	12.58	32.44	43.63	11.35	.52	.21	26.50	23.13	19.90
" No. 6	13.19	32.31	39.62	14.88	.69	.23	25.80	22.34	18.88
Indiana No. 1, briquettes	11.74	38.79	43.23	6.24	.54	.144	24.55	21.70	20.05
" No. 1, washed	16.59	35.17	40.41	7.83	.485	.130	26.80	22.39	20.40
" No. 2	9.11	38.04	40.40	12.45	.516	.165	22.55	20.51	18.00
Indian Territory No. 1	7.65	33.96	46.30	12.09	.306	.122	20.75	19.17	16.40
" No. 2	3.71	36.21	50.31	9.77	.339	.124	22.25	21.50	18.90
" No. 3	4.79	37.30	47.58	10.33	.490	.180	22.46	21.43	18.05
" No. 4	6.24	35.44	45.33	12.99	.590	.210	22.41	21.04	18.50

TABLE LXXIX—*Continued*

RATE OF COMBUSTION OF COAL

U. S. GEOLOGICAL SURVEY TESTS

Coal.	Proximats Coal Analysis.				Draft, Inches, H_2O.		Pounds per Square Foot per Hour.		
	Moisture.	Volatile.	Fixed C.	Ash.	Hood.	Furnace.	As Fired.	Dry.	Com-bustible.
Iowa No. 1	8.69	33.08	39.89	18.34	.460	.150	25.42	23.23	18.60
" No. 2	14.88	35.35	33.73	16.04	.620	.210	27.30	23.28	19.20
" No. 3	12.44	36.14	35.77	15.65	.580	.220	26.22	22.96	19.43
" No. 4	13.48	34.09	37.28	15.15	.500	.193	23.15	20.02	16.80
" No. 4, briquettes	13.24	36.50	37.85	12.41	.590	.220	24.30	21.11	18.15
" No. 5	16.01	31.76	38.83	13.04	.510	.220	27.61	23.23	20.00
Kansas No. 1	5.90	33.78	49.46	10.86	.430	.240	17.62	16.60	14.80
" No. 1	4.80	32.68	48.57	13.95	.390	.140	19.10	18.13	15.53
" No. 2	4.18	31.23	46.68	17.91	.470	.220	19.70	18.90	16.68
" No. 2, washed	5.82	34.32	51.22	8.64	.390	.160	21.30	20.08	17.85
" No. 3	2.03	33.52	50.99	13.46	.416	.142	19.20	18.77	16.17
" No. 3	2.25	34.30	51.05	12.40	.410	.250	16.82	16.45	14.30
" No. 4	5.51	36.32	43.59	14.58	.510	.190	19.21	18.18	15.65
" No. 5	4.31	32.42	51.36	11.91	.520	.170	21.53	20.62	18.10
Kentucky No. 1	2.89	35.61	55.59	5.91	.400	.150	20.50	19.95	18.40
" No. 2	7.76	37.91	45.75	8.58	.460	.160	23.58	21.75	19.38
" No. 2, briquettes	7.11	37.07	44.32	11.50	.490	.170	23.52	21.87	19.18
" No. 3	7.92	37.32	44.84	9.92	.470	.120	23.64	21.75	19.52
" No. 4	5.89	36.65	45.74	12.72	.550	.195	23.27	21.90	19.05
Missouri No. 1	7.28	34.88	40.64	17.20	.400	.170	24.00	22.30	18.00
" No. 1, briquettes	6.38	37.60	41.85	14.17	.440	.170	21.70	20.37	17.15
" No. 1, washed	7.93	36.81	44.21	11.05	.370	.160	22.45	20.71	18.23
" No. 2	13.09	32.88	37.33	16.70	.623	.198	28.74	25.00	19.88
" No. 2	11.57	31.77	39.76	16.90	.323	.130	22.82	20.20	16.95
" No. 3	18.63	26.18	29.98	25.51	.700	.280	26.75	21.85	15.70

Missouri No. 3, washed	20.78	31.18	39.61	8.43	.650	.260	27.42	21.72	19.10
" No. 4	12.24	40.10	42.11	5.55	.520	.160	23.45	20.64	19.21
New Mexico No. 1	11.90	37.85	41.57	8.68	.360	.140	26.80	23.70	21.60
" No. 2	9.92	37.30	36.11	16.67	.490	.230	29.22	26.37	19.71
" No. 2, briquettes	6.75	37.56	39.07	16.62	.540	.210	23.83	22.00	16.75
North Dakota No. 1, lignite	35.84	28.13	25.40	10.63	.575	.325	26.65	17.15	15.20
Pennsylvania No. 1	1.10	15.80	75.69	7.41	.480	.165	15.88	15.70	15.00
" No. 2	.59	16.61	76.76	6.04	.310	.153	16.72	16.60	16.10
" No. 3, briquettes	3.00	27.62	55.00	14.38	.610	.250	19.60	19.01	15.08
" No. 4	2.90	28.70	60.82	7.58	.450	.190	19.20	18.67	17.08
Texas No. 1, lignite	23.27	31.42	29.44	15.87	.520	.340	13.54	10.38	7.80
West Virginia No. 1	1.90	34.64	56.25	7.21	.310	.130	19.33	18.94	17.47
" No. 2	2.01	39.23	48.80	9.96	.460	.240	20.18	19.75	17.78
" No. 3	2.54	30.31	56.11	11.04	.500	.200	20.35	19.82	17.42
" No. 4	2.53	27.64	59.84	9.99	.480	.180	19.70	18.98	16.98
" No. 5	2.11	28.95	58.66	10.28	.510	.190	18.85	18.44	16.47
" No. 6	2.14	22.38	70.03	5.45	.450	.160	18.37	17.95	16.70
" No. 6	2.11	21.44	71.42	5.03	.463	.181	17.87	17.21	16.27
" No. 7	2.68	20.23	68.27	8.82	.530	.217	18.70	18.15	16.63
" No. 8	5.26	31.19	56.68	6.87	.370	.120	19.73	18.72	16.80
" No. 9	3.42	31.11	59.47	6.00	.500	.180	18.40	17.78	16.35
" No. 10	1.74	18.23	73.84	6.19	.380	.170	18.45	18.15	16.62
" No. 11	4.85	16.31	68.36	10.48	.520	.220	19.05	18.13	15.58
" No. 12	1.58	18.26	75.33	4.83	.435	.175	18.00	17.68	16.30
" No. 12, briquettes	2.32	24.02	67.46	6.20	.410	.140	18.15	17.66	15.90
Wyoming No. 1, lignite	21.81	40.56	31.61	6.02	.620	.230	28.95	22.69	20.68
" No. 2	11.10	35.55	34.58	18.77	.490	.140	29.80	26.51	19.80

TABLE LXXX

DIAGRAM FACTORS FOR OTTO CYCLE GAS ENGINES

Engine.	Size in Inches. Bore.	Stroke.	Test Authority.	Compression. Vol. before / Vol. after	Press. after / Press. before	Efficiencies, Per Cent. Actual.	Air Card Standard.	Diagram Factor.
Four cycle.......	7.8	11.8	Meyer	......	3.73–6.45	25	44	.58
					" "	24.4	42	.58
					" "	21.4	37	.58
					" "	18.8	33	.57
Four cycle.......	6	12	Burstall	......	3.03–8.13	18.9	33	.57
	6	12	"	......	3.03–8.13	21.2	36	.59
	6	12	"	......	3.03–8.13	21.9	43	.51
	6	12	"	......	3.03–8.13	23.1	47	.49
	6	12	"	......	3.03–8.13	16.6	33	.50
	6	12	"	......	3.03–8.13	18.7	36	.52
	6	12	"	......	3.03–8.13	17.2	43	.40
	6	12	"	......	3.03–8.13	18.1	47	.38
40 H.P. four cycle	....	....	Hopkinson	6.37	....	33.5–37.0 depending upon load	52	.64–.71
Cockerill........	51.18	55.07	Hubert	......	9.18	22.9	46.9	.49
"	33.465	39.37	"	......	10.35	25.0	48.7	.514
Delamarre.......	22.64	37.4	Witz	......	5.8	19.75	39.7	.498
Cockerill........	23.622	31.5	François	......	7.28	24.3	43.4	.56
Letombe........	23.622	31.5	Witz	......	8.03	27.3	45.0	.606
Winterthur......	20.47	29.92	Allaire	......	11.2	25.6	49.9	.514
Cie. Berlin Anhalt	16.92	27.56	Witz	......	8.17	26.9	45.2	.595
Benz...........	16.73	22	Mathot	......	13.06	23.8	52.0	.457
Soest...........	15.75	22.83	"	......	7.35	31.3	43.6	.718
Deutz..........	14.173	22.87	"	......	11.55	30.4	50.3	.605
Tangye.........	14.5	22	"	......	4.83	30.6	36.2	.845
Fetu...........	13.78	22	"	......	9.12	18.0	46.9	.384
Schmitz.........	13.78	21.26	"	......	9.12	24.2	46.9	.515
Otto-Deutz......	13	22.83	"	......	9.4	38.8	47.3	.82
Niel............	13.78	19	Witz	......	11.58	31.8	50.4	.63
Winterthur......	12.2	17.7	Mathot	......	7.75	31.6	44.5	.71
Schmitz.........	11.85	18	"	......	11.3	31.3	50.1	.625
Winterthur......	11.8	17.7	"	......	10.32	25.2	48.7	.518
Benier..........	11.8	17.3	Witz	......	4.39	13.75	34.3	.4
Tangye.........	11	20	Mathot	......	10.64	29.8	49.2	.605
Dudbridge.......	11	18.6	"	......	4.83	29.2	36.4	.802
Tangye.........	10	19	"	......	5.81	27.4	39.7	.69
"	10	19	Witz	......	6.8	30.1	42.4	.71
National........	10	18	Mathot	......	5.88	21.2	39.9	.53
Güldner.........	9.85	15.75	Schrotter	......	10.6	39.0	49.1	.795
"	9.85	15.75	"	......	10.6	33.9	49.1	.69
Catteau.........	9	18	Witz	......	12.59	37.2	51.5	.723
Tangye.........	7	16	Hirsch	......	10.2	25.8	48.6	.53
Four cycle.......	6	12	Burstall	4	....	21.0	42.8	.49
"	6	12	"	2.44	....	18.0	29.6	.608
"	6	12	"	4	....	18.0	42.8	.42
"	6	12	"	2.78	....	17.6	33.3	.529
"	6	12	"	2.7	....	16.4	32.7	.502

Table LXXX—*Continued*
DIAGRAM FACTORS FOR OTTO CYCLE ENGINES

Engine.	Size in Inches. Bore.	Size in Inches. Stroke.	Test Authority.	Compression. Vol. before / Vol. after	Compression. Press. after / Press. before	Efficiencies, Per Cent. Actual.	Efficiencies, Per Cent. Air Card Standard.	Diagram Factor.
Four cycle.......	6	12	"	2.04	....	16.2	34.6	.468
"	6	12	"	2.17	....	15.6	26.2	.595
"	6	12	"	4.0	....	13.6	42.8	.318
"	6	12	"	4.0	....	13.4	42.8	.313
"	6	12	"	1.75	....	12.6	19.5	.646
"	6	12	"	2.7	....	11.7	32.7	.358
"	6	12	"	2.22	....	19.4	26.9	.721
"	6	12	"	2.94	....	20.0	35.0	.572
"	6	12	"	4.0	....	22.7	42.8	.53
"	8½	13	Meyer	3.75	....	32.7	41.2	.794
"	8½	13	"	3.6	....	26.8	40.3	.665
"	8½	13	"	2.84	....	20.2	35.2	.574

Compression pressure ratio has been calculated assuming an initial pressure of 14.7 lbs. per square inch.

Table LXXXI
HEAT BALANCES OF GAS AND OIL ENGINES (Per Cent of Gas or Oil Heat)

Engine and Authority.	I.H.P.	B.H.P.	Friction.	Exhaust.	Jacket.	Radiation and Unaccounted for.
Donkin........................	22.32	......	......	43.29	32.96	1.43
Beck engine, Kennedy...........	19.4	......	......	42.9	33.0	4.7
Griffin engine, Kennedy..........	21.1	......	......	39.8	35.2	3.9
Atkinson engine, Kennedy......	25.5	......	......	37.9	27.0	9.6
Otto Crossley engine, Kennedy....	22.1	......	......	35.5	43.2	.8 excess
Comp. Ratio. R.P.M. *a/g* (Air-gas)						
2.67 187 7.11, Slaby	18.0	......	......	30.8	51.2	
2.67 247 7.35, Slaby	18.1	......	......	36.3	45.6	
4.32 187 7.43, Slaby	24.4	......	......	21.8	53.8	
4.32 247 7.40, Slaby	23.7	......	......	26.8	49.5	
General, Mathot................	33.0	28.0	5.0	31.0*	36.0	
Westinghouse, Bibbins...........	29.48	24.9	4.58	36.3	34.22	
300 H.P. engine at 197 H.P., Eberly	43.5	33.5	10.0 †	24.1	34.3	1.9 excess
" " 294 H.P., Eberly	45.8	32.2	13.6 †	23.9	31.8	1.5 "
" " 335 H.P., Eberly	41.5	30.9	10.6 †	24.8	33.8	.1 "
6 H.P. engine, I.C.E............	31.8	26.7	5.1	41.1	27.1 ‡	
24 H.P. engine, I.C.E...........	33.3	28.3	5	37.1	29.6 ‡	
Deutz 2 H.P., Wimplinger......	21.5	16.1	5.4	25	50.4	3.1
Güldner 20 H.P., Schröter........	42.7	......	......	24.1	33.2	
Walrath 75 H.P., Geer and Yanelain........................	27.1	21.3	5.8	23.4	49.5	
300 H.P., Goldsmith and Hartwig........................	24.4	17.1	7.3	50.6	25.0	
Hornsby, Robinson..............	21	18	3	29	50	
De la Vergne F. H., Towl........	40.14	27.52	12.62	20.03	26.50	13.33
Pierce-Arrow, Chase.............	......	18	......	......	29.4	

* Including radiation. † Including pumps. ‡ Including external radiation.

Table LXXXII

MEAN EFFECTIVE PRESSURE FACTORS FOR OTTO CYCLE ENGINES

$$(\text{m.e.p}') = 5.4\,F\frac{H}{a+1}\left[1-\left(\frac{Pa}{Px}\right)^{\frac{\gamma-1}{\gamma}}\right] \qquad \text{Eq. (933)}$$

$\frac{Px}{Pa}$ Atmos	$\left(\frac{Pa}{Px}\right)^{\frac{5}{7}}$	$\left[1-\left(\frac{Pa}{Px}\right)^{\frac{2}{7}}\right]$	$5.4\left[1-\left(\frac{Pa}{Px}\right)^{\frac{2}{7}}\right]$
1.0	1 1.000	.0000	.000
1.2	.878 9.43442–10	.0508 8.705522–10	.274 9.438140–10
1.4	.786 9.895623–10	.0917 8.962180–10	.495 9.694798–10
1.6	.715 9.854271–10	.1256 9.098990–10	.679 9.831608–10
1.8	.656 9.817662–10	.1546 9.189181–10	.835 9.921799–10
2.0	.610 9.784979–10	.1797 9.254451–10	.971 9.987069–10
2.2	.569 9.755412–10	.2017 9.304706–10	1.090 .037324
2.4	.535 9.728421–10	.2213 9.344981–10	1.196 .077599
2.6	.505 9.703591–10	.2389 9.378234–10	1.291 .110842
2.8	.479 9.680601–10	.2549 9.406300–10	1.377 .138918
3.0	.456 9.659199–10	.2694 9.430398–10	1.456 .163016
3.2	.436 9.639179–10	.2827 9.451403–10	1.528 .184021
3.4	.417 9.620372–10	.2951 9.469925–10	1.594 .202543
3.6	.401 9.602641–10	.3065 9.486402–10	1.656 .219020
3.8	.385 9.585869–10	.3171 9.501223–10	1.713 .233841
4.0	.372 9.569957–10	.3271 9.514615–10	1.767 .247233
4.2	.359 9.554822–10	.3364 9.526804–10	1.817 .259422
4.4	.347 9.540391–10	.3451 9.537983–10	1.865 .270601
4.6	.336 9.526601–10	.3534 9.548255–10	1.909 .280873
4.8	.327 9.513399–10	.3612 9.557760–10	1.952 .290378
5.0	.3168 9.500736–10	.3686 9.566579–10	1.991 .299197
5.2	.3080 9.488569–10	.3757 9.574794–10	2.030 .307413
5.4	.2998 9.476861–10	.3823 9.582461–10	2.066 .315079
5.6	.2921 9.465580–10	.3887 9.589648–10	2.100 .322266
5.8	.2849 9.454694–10	.3948 9.596410–10	2.133 .329028
6.0	.2781 9.444178–10	.4007 9.602776–10	2.165 .335394
6.2	.2716 9.434006–10	.4063 9.608794–10	2.195 .341414
6.4	.2656 9.424157–10	.4116 9.614486–10	2.224 .347104
6.6	.2598 9.414611–10	.4168 9.619886–10	2.252 .352504
6.8	.2543 9.405351–10	.4217 9.625025–10	2.278 .357643
7.0	.2491 9.396359–10	.4265 9.629909–10	2.304 .362527
7.2	.2441 9.387620–10	.4311 9.634558–10	2.329 .367176
7.4	.2394 9.379120–10	.4355 9.639008–10	2.353 .371626
7.6	.2349 9.370847–10	.4398 9.643265–10	2.376 .375883
7.8	.2306 9.362789–10	.4439 9.647334–10	2.399 .379952
8.0	.2264 9.354936–10	.4480 9.651239–10	2.440 .383857
8.2	.2225 9.247276–10	.4518 9.654984–10	2.446 .387602
8.4	.2187 9.339801–10	.4556 9.658584–10	2.462 .391202
8.6	.2150 9.332501–10	.4592 9.662040–10	2.481 .394658
8.8	.2115 9.325369–10	.4628 9.665384–10	2.500 .398002
9	.2082 9.318398–10	.4662 9.668591–10	2.519 0.401209
10	.1931 9.285714–10	.4821 9.683092–10	2.604 .415710
11	.1804 9.256148–10	.4960 9.695456–10	2.680 .428074
12	.1695 9.229156–10	.5083 9.706154–10	2.746 .438172
13	.1601 9.204328–10	.5195 9.715552–10	2.807 .448170
14	.1518 9.181337–10	.5295 9.723891–10	2.861 .456509
15	.1445 9.159935–10	.5378 9.731355–10	2.911 .463973
16	.1380 9.139914–10	.5471 9.738099–10	2.956 .470717
17	.1322 9.121108–10	.5549 9.744231–10	2.998 .476849
18	.1269 9.103376–10	.5621 9.749837–10	3.037 .482455
19	.1221 9.086604–10	.5688 9.754990–10	3.073 .487608
20	.1177 9.070693–10	.5751 9.799751–10	3.107 .492369
21	.1136 9.055556–10	.5810 9.764169–10	3.139 .496787
22	.1099 9.041126–10	.5865 9.768283–10	3.169 .500901
23	.1065 9.027337–10	.5915 9.772131–10	3.197 .504749
24	.1033 9.014135–10	.5967 9.775741–10	3.224 .508359
25	.1003 9.001471–10	.6014 9.779127–10	3.249 .511745
26	.0976 8.989305–10	.6058 9.782339–10	3.273 .514947
27	.0950 8.977597–10	.6100 9.785344–10	3.296 .517962
28	.0925 8.966316–10	.6141 9.788204–10	3.318 .520822
29	.0902 8.955430–10	.6179 9.790918–10	3.338 .523536
30	.0881 8.944914–10	.6215 9.793504–10	3.358 .526122
31	.0860 8.934741–10	.6251 9.795963–10	3.377 .528581
32	.0841 8.924893–10	.6285 9.798305–10	3.396 .530923
33	.0823 8.915347–10	.6318 9.800546–10	3.413 .533164
34	.0806 8.906086–10	.6349 9.802691–10	3.430 .535309
35	.0789 8.897094–10	.6379 9.804746–10	3.446 .537364
36	.0773 8.888355–10	.6408 9.807623–10	3.462 .539341
37	.0758 8.879056–10	.6436 9.808616–10	3.477 .541234
38	.0744 8.871583–10	.6463 9.810434–10	3.492 .543052
39	.0730 8.863525–10	.6489 9.812192–10	3.506 .544810
40	.0717 8.855671–10	.6514 9.813881–10	3.520 .546499
41	.0705 8.848011–10	.6539 9.815511–10	3.533 .548129
42	.0693 8.840733–10	.6563 9.817082–10	3.546 .549700
43	.0681 8.833147–10	.6586 9.818609–10	3.558 .551227
44	.0670 8.826105–10	.6608 9.820076–10	3.570 .552694

Table LXXXIII

VALUES OF C FOR AIR FLOW (Weisbach)

Orifice of diameter = .394 ins.

R_P....	1.05	1.09	1.43	1.65	1.89	2.15
C......	.555	.589	.692	.724	.754	.788

Orifice of diameter = .843 ins.

R_P....	1.05	1.09	1.36	1.67	2.01
C......	.558	.573	.634	.678	.723

Short tube, diameter = .394 ins.and length = 1.181 ins.

R_P....	1.05	1.10	1.30
C......	.730	.771	.830

Short tube, diameter = .557 and length = 1.673 ins.

R_P....	1.41	1.69
C......	.813	.822

Short tube, diameter = .394 ins. and length = .630 ins. rounded entrance

R_P....	1.24	1.38	1.59	1.85	2.14
C......	.979	.986	.965	.971	.978

C = coefficient of friction in formula $v=C\sqrt{2gh}$
R_P = ratio of pressures.

The coefficient of efflux, C_e, Weisbach gives as follows:

For conoidal mouthpiece with pressures from 0.23 to 1.1 atm.	C_e = .97 to .99
Circular orifices in thin plates,	= .56 to .79
Short cylindrical mouthpieces,	= .81 to .84
The same rounded at inner end,	= .92 to .93
Conical converging,	= .90 to .99

Table LXXXIV

FLOW CHANGE RESISTANCE FACTORS F_R (Reitschel)

Condition.	Resistance Factor F_R
Sharp 90° elbow	1.1
" 135° elbow	.3
Long bend: r = width of duct	.25
" r = 2 to 4 duct widths	.15
" r = 5 to 6 duct widths	.07
Long bend 135°	.15
Long double offset	.4 to .1
Outlet register with valves $\frac{2}{3}$ free area and 2×flue area	.6
" " face at $\frac{2}{3}$ free area	.4
" wire screens 1.5×flue area	0.0
Entrance for square corners	1.0
" rounded corners	.5 to .2
" flue extending into header as short pipe	1.5
Enlargement of area from A_1 to A_2, sharp corners	$\left(\frac{A_2}{A_1}-1\right)^2$
Reduction of area from A_2 to A_1, sharp corners	$\left(1+\frac{A_1}{A_2}\right)^2$
Free discharge into room when velocity becomes zero	1.0

TABLE LXXXV

PISTON STEAM ENGINE AND TURBINE EFFICIENCY FACTORS REFERRED TO THE RANKINE CYCLE AS A STANDARD OF REFERENCE

	Description of Engine.	Initial Condition.		Back Pressure.		Water Rate, Lbs. per Hr. per I.H.P.	Efficiency Per Cent.		Efficiency Factor, Actual Effi. / Rankine Cyc.
		Abs. Press. Lbs. per Sq.in.	Quality.	Lbs. per Sq.in.	Inches Hg Absolute.		Actual.	Rankine Cycle.	
Stationary Piston Engines, General Power	Non-cond. Corliss compound, 12×22×20″, 200 R.P.M	152	Dry sat.	14.7	29.92	19	13.4	17	.78
	Non-cond. four-valve simple, 14×18″, 200 R.P.M......	165	" "	14.7	29.92	23	10.9	17.3	.63
	Manhattan Ry., 7000 KW. cross-compound Corliss, 44×88×60″, 75 R.P.M........................	190	98% dry	2	4.23	11.74	19.2	29.5	.65
	Corliss compound, Boston El. Ry., 44×87×60″, 74 R.P.M....................................	163	70° F. Superheat	2.9	5.91	12.08	18.7	24.9	.75
	Allis-Corliss compound Boston El. Ry., 28×56×60″, 72 R.P.M....................................	163	Dry sat.	2.0	4.07	14.05	16.8	26.2	.63
	Fleming four-valve, 15×40.5×27″, 150 R.P.M.......	164	" "	1.96	4.00	12.33	18.7	26.5	.71
	Corliss simple non-condensing, 250 H.P., 17×16″....	115	" "	14.7	29.92	26	9.7	14.8	.66
	Corliss simple non-condensing, 132 H.P., 16×16″....	140	" "	14.7	29.92	21.3	11.8	16.2	.73
	Corliss cross-compound, 30×56×72″, 65 R.P.M., Denton..	138	14° sup.	2.1	4.28	13.5	17	25.3	.68
	Corliss angle comp. cond., Interboro Power House, N. Y., 42×86×60″, 75 R.P.M.................	190	9° sup.	.94	1.91	12.59	17.8	29.6	.60
	As above non-condensing, Stott..................	199	98.7% dry	16.1	.....	18.06	14	18.2	.77
	Corliss cross-compound, 16×28×42″, 102 R.P.M., Jacobus..	157	375° sup.	1.5	3.07	9.56	20.4	29.3	.70
	Willans single valve non-cond., 14×6″, 400 R.P.M...	137	Dry sat.	14.7	29.92	26	9.67	16.0	.60
	McIntosh and Seymour, 1000 H.P., 100 R.P.M., Dean	138	20° sup.	1.39	2.82	12.76	17.75	26.9	.66
	Ball compound non-cond., 12×20×13″, 271 R.P.M..	182	Dry sat.	14.7	29.92	21.14	11.7	17.9	.65
	Sulzer 4-cylinder triple-expansion, 32×47×58×59″, 85 R.P.M....................................	188	230° sup.	.98	2	8.97	22.6	30.8	.73
	Cole, Marchent & Morley cross-comp. jacketed, 21×36×36″, 101 R.P.M.........................	129	202° sup.	.85	1.72	8.58	24	30.8	.78
	White automobile, 3×6×4.5″, 850 R.P.M.........	441	316° sup.	14.7	29.92	11.96	17.4	25.6	.68
	Westinghouse vertical, 5400 H.P., 76 R.P.M.........	200	Dry sat.	1.29	2.62	11.93	19.05	28.8	.66

Stationary Piston Engines, Pumping	Snow pumping engine triple, Louisville, 30×56.5×84 ×60″, Corliss	170	110° sup.	1.15	2.36	9.65	22.25	28.7	.78
	Snow pumping engine triple, Cleveland, 12.75×24×36 ×24″,	164	Dry sat.	1.19	2.43	11.51	19.75	27.5	.72
	Leavitt pumping engine, 576 H.P., 11 R.P.M., Miller.	191	" "	1.29	2.62	11.20	20.3	28.1	.72
	Holly duplex Comp. pumping engine, 21×42×36″×20 R.P.M. Heck	97	99.1% dry	2.0	4.07	15.63	15.3	23.1	.66
	Allis-Chalmers triple-exp. vert. pumping engine, 28×48×74×60″, 20 R.P.M	136	98.9% "	1.2	2.44	11.8	19.7	27.4	.72
	Snow pumping engine, triple, Indianapolis, 29, 52, 80×60″, 21 R.P.M.	169	99% dry	1.6	3.26	11.5	20.7	28.0	.74
	Leavitt pumping engine, Louisville, Ky., 27×54×120″, 19 R.P.M.	152	99.4%	1	4.23	12.22	19.4	29.4	.66
	Nordberg pumping engine, 19.5×29×49½×57½×42″, 36 R.P.M.	215	Dry sat.	.9	1.83	12.26	22.8	30.7	.74
	Allis triple-exp. pumping engine, Boston, 30×56, 87×66″, 17 R.P.M	200	" "	.85	1.73	10.33	21.63	30.7	.70
	Allis triple-exp. pumping engine, Bissel's Point, 34×94×72″, 17 R.P.M	155	" "	1.2	2.44	10.59	21.06	28.1	.75
	Holly triple-exp. pumping engine, Boston, 22×41×62×60″, 25 R.P.M	165	" "	1.05	2.14	11.01	20.85	29.8	.70
	Worthington triple-exp. pumping engine, Chicago, 650 H.P., 19 R.P.M	162	87.2° sup.	.79	1.6	10.00	21.6	29.8	.72
	Riedler triple-exp. pumping engine, Chicago, 15×29×48×48″, 62 R.P.M	185	166.3° sup.	1.28	2.6	9.73	21.6	31.2	.69
Compressor	Comp. two-stage Nordberg compressor, Tennessee Copper Co., 1905, Channing	164	98.7% dry	2.09	4.26	15.19	15.5	25.7	.60
Locomotive	Locomotive test, Purdue Univ., 16×34″, superheated steam, Goss	215	231° sup.	15	......	18.9	11.8	20.3	.58
	As above, dry sat. steam	215	Dry sat.	15	......	25.5	9.8	19.0	.52
	Pennsylvania R.R. cross comp., 2 cyl. consolidation, 23×35×32″, 80 R.P.M	223	98.4% dry	19.4	......	19.86	12.5	19.3	.65
	Pennsylvania R.R., 4 cyl. Atlantic, 14.2×13.7×25.2″, 160 R.P.M	218	98.8% dry	18.7	......	20.14	12.4	19.3	.64

TABLE LXXXV—*Continued*

PISTON STEAM ENGINE AND TURBINE EFFICIENCY FACTORS REFERRED TO THE RANKINE CYCLE AS A STANDARD OF REFERENCE

	Description of Engine.	Initial Condition.		Back Pressure.		Water Rate, Lbs. per Hr. per I.H.P.	Efficiency Per Cent.		Efficiency Factor, Actual Effi. / Rankine Cyc.
		Abs. Press. Lbs. per Sq.in.	Quality.	Lbs. per Sq.in.	Inches Hg Absolute.		Actual.	Rankine Cycle.	
Locomotive	Pennsylvania R.R. compound locomotive, 14.2×26.1×23.6″, 240 R.P.M	203	91° sup.	17.8	......	17.61	13.4	19.0	.71
	Locomotive No. 1499, Penn. system, 22×28″, 120 R.P.M.	211	Dry sat.	15	......	23.4	10.7	18.8	.56
Reciprocating Steamship	Steamship Meteor, triple-exp. engine, 29×44×70×48″, 72 R.P.M	153	98.5% dry	2.7	5.45	14.98	16	25	.64
	Steamship Iona, triple-exp. engine, 22×34×57×39″, 61 R.P.M.	180	98.5% "	.7	1.42	13.35	17.1	30.5	.56
	Steamship Saxonia, quad.-exp. engine, 29×41.5×59″, 84×54″, 78 R.P.M	207	98.5% "	2.3	4.70	13.47	17.4	26.8	.65
	Westinghouse marine compound, 17×27×24″, non-condensing	163	Dry sat.	14.7	29.92	19.3	13.0	17.1	.76
	As above, condensing	162	" "	4	8.14	16.9	14.0	23.4	.60
	Inverted vert. marine cross-compound, 21×36×36″, 101 R.P.M	132	242° sup.	1.47	3	9.26	21	29.2	.72
	Steamship Otaki, triple-exp., 24.5×39.58×39″, and Parsons low-pressure turbine	193	Dry sat.	.93	1.9	13.66	16.5	29.6	.56
Turbine	Curtis turbine, 5000 KW., Port Morris Station, N. Y. C. R. R.	190	150° sup.	.98	2.0*	11.9	17.64	30.1	.59
	As above	190	Dry sat.	.98	2.0	13.4	16.85	29.5	.57
	De Laval 200 KW., Dean	223	81° sup.	1.34	2.72	12.2	17.85	29.4	.61
	Westinghouse 10,000 KW., N. Y. Edison	192	97° "	1.28	1.61	9.57	22.4	29.8	.75
	Westinghouse 10,000 KW., City Electric	182	59° "	1.99	2.02	9.29	23.6	29.5	.80
	Curtiss 10,000 KW., Chicago Edison	191	147° sup.	.22	.45	8.23	24.7	34.6	.71
	Parsons 5000 K.W., Carville	209	95° sup.	.32	.65	8.52	24.5	33.8	.72
	Parsons 3500 KW., Brown-Buveri, Frankfort	157	130° sup.	.50	1.02	8.74	24.0	31.1	.77

Turbine								
Zoelly 3500 KW., Escherwyss, Turin	187	90° sup.	.77	1.57	9.58	22.4	30.4	.74
Curtis Rateau 4000 KW., Rummelsburg, A.E.G	188	285° sup.	.45	.92	7.59	25.8	33.4	.77
Westinghouse 1000 KW	169	140° "	94	1.92	10.8	19.5	29.5	.66
Rateau multicellular, 500 H.P.	152	Dry sat.	1.58	3.22	13.42	17.2	26.7	.65
Westinghouse Parsons 1250 KW.	165	" "	14.7	29.92	21.64	11.6	17.3	.67
De Laval 10 KW.	115	" "	14.7	29.92	41.5	6.1	14.7	.41
Curtis 75 KW.	165	" "	14.7	29.92	29.9	8.4	17.3	.48
Westinghouse Parsons 7500 KW., Int. Rapid Transit, N. Y.	198	97% dry	1.12	2.3	10.27	22.1	30.7	.72
Westinghouse 1000 KW., low-pressure turbine	17.4	Dry sat.	1.97	4.02	25.11	9.6	13.2	.73
Rateau 1000 KW.	179	10° sup.	2.43	4.95	14.0	16.5	26	.63
Kerr 150 H.P.	190	Dry sat.	14.7	29.92	33.6	10.6	18.2	.58
Elektra 200 KW.	201	172° sup.	1.18	2.40	13.42	15.6	29.9	.52
Reidler Stumpf 1400 KW.	205	170° "	2.19	4.46	12.50	17	29	.59
Zoelly 3500 KW.	182	170° "	.53	1.09	8.71	23.15	34.0	.68
Melms Pfenninger 500 KW	189	230° "	.50	1.02	10.42	19.15	35.7	.54
Curtis 5000 KW., low-pressure, Stott and Pigott	16.1	92.1% dry	.46	.94	17.8	7.6	13.3	.57
Rateau 500 KW., low pressure	14.7	97.1% "	.98	1.99	23.1	10.3	18.9	.54

* Water rate in pounds per I.H.P. hr. for turbines has been calculated from data given, by assuming electric generator efficiency =95 per cent, and mechanical efficiency =90 per cent.

Table LXXXVI

DIMENSIONS OF CHIMNEYS BY KENT'S FORMULA

Diameter in Inches	Area in Square Feet	Height of Chimney in Feet																					Equivalent square chimney. Side of square inches	Diameter in inches
		80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200
		Commercial Horse-power																						
30	4.91	107	110																						27	30
33	5.94	133	137																						30	33
36	7.07	163	168	173																					32	36
39	8.30	196	202	208	214																				35	39
42	9.62	231	238	245	251	258	265	271																	38	42
48	12.57	311	320	330	339	348	356	365	373	381	389	396													43	48
54	15.90		415	427	438	449	461	472	482	493	503	513	523	532	542										48	54
60	19.64			536	551	565	579	593	606	619	632	644	657	669	680	692	704	715							54	60
66	23.76				676	694	711	728	744	760	776	791	806	821	835	849	864	877	891	904	918				59	66
72	28.27					835	856	876	896	913	934	952	970	988	1006	1023	1040	1056	1073	1089	1105	1120	1136	1151			64	72
78	33.18						1014	1038	1062	1084	1107	1129	1150	1171	1192	1212	1232	1252	1272	1291	1310	1328	1346	1364	1382	1400	70	78
84	38.48							1214	1241	1268	1294	1320	1345	1370	1394	1418	1441	1464	1487	1509	1531	1553	1574	1595	1616	1637	75	84
90	44.18								1435	1466	1496	1526	1555	1584	1612	1639	1666	1693	1719	1745	1771	1795	1820	1845	1869	1893	80	90
96	50.27								1643	1678	1713	1747	1780	1813	1845	1876	1907	1938	1968	1998	2027	2056	2084	2112	2140	2167	86	96
102	56.75									1905	1944	1983	2021	2058	2094	2130	2165	2200	2234	2268	2301	2333	2366	2397	2429	2459	91	102
108	63.62										2190	2234	2276	2318	2359	2399	2439	2478	2516	2554	2592	2628	2664	2700	2736	2771	96	108
114	70.88											2499	2547	2594	2640	2685	2729	2773	2816	2858	2900	2941	2982	3022	3061	3100	101	114
120	78.54												2833	2885	2936	2986	3036	3084	3132	3179	3226	3271	3316	3361	3405	3448	107	120
132	95.03												3450	3514	3576	3637	3697	3756	3815	3872	3929	3984	4039	4093	4147	4200	117	132
144	113.10													4205	4279	4352	4424	4495	4565	4632	4701	4768	4834	4899	4963	5026	128	144

H = height in feet; A = area in square feet; effective area, $E = A - 0.6\sqrt{A}$ square feet.
Boiler horse-power = $0.333\,(A - 0.6\sqrt{A})\sqrt{H}$ for circular stacks. Assuming 1 H.P. corresponds to 5 pounds of coal burned per hour.

Table LXXXVII

THEORETICAL DRAFT PRESSURE IN INCHES OF WATER* IN A CHIMNEY 100 FT. HIGH

(For other heights the draft varies directly as the height)

Temperature in Chimney Fahr.	Temperature of External Air (Barometer 30 Ins.)										
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
200°	0.453	0.419	0.384	0.353	0.321	0.292	0.263	0.234	0.209	0.182	0.157
220	0.488	0.453	0.419	0.388	0.355	0.326	0.298	0.269	0.244	0.217	0.192
240	0.520	0.488	0.451	0.421	0.388	0.359	0.330	0.301	0.276	0.250	0.225
260	0.555	0.528	0.484	0.453	0.420	0.392	0.363	0.334	0.309	0.282	0.257
280	0.584	0.549	0.515	0.482	0.451	0.422	0.394	0.365	0.340	0.313	0.288
300	0.611	0.576	0.541	0.511	0.478	0.449	0.420	0.392	0.367	0.340	0.315
320	0.637	0.603	0.568	0.538	0.505	0.476	0.447	0.419	0.394	0.367	0.342
340	0.662	0.638	0.593	0.563	0.530	0.501	0.472	0.443	0.419	0.392	0.367
360	0.687	0.653	0.618	0.588	0.555	0.526	0.497	0.468	0.444	0.417	0.392
380	0.710	0.676	0.641	0.611	0.578	0.549	0.520	0.492	0.467	0.440	0.415
400	0.732	0.697	0.662	0.632	0.598	0.570	0.541	0.513	0.488	0.461	0.436
420	0.753	0.718	0.684	0.653	0.620	0.591	0.563	0.534	0.509	0.482	0.457
440	0.774	0.739	0.705	0.674	0.641	0.612	0.584	0.555	0.530	0.503	0.478
460	0.793	0.758	0.724	0.694	0.660	0.632	0.603	0.574	0.549	0.522	0.497
480	0.810	0.776	0.741	0.710	0.678	0.649	0.620	0.591	0.566	0.540	0.515
500	0.829	0.791	0.760	0.730	0.697	0.669	0.639	0.610	0.586	0.559	0.534

* *The available draft* will be the tabular values less the amount consumed by friction in the stack. In stacks whose diameter is determined by Eq. 1005 the *net* draft will be 80 per cent of the tabular values. Hence to obtain from the table the height of stack necessary to produce a net draft of say 0.6 in., the theoretical draft will be $0.6 \times 1.25 = 0.75$ in., which can be obtained with a stack 100 ft. high with flue-gas temperature of 420° F., and air temperature of 0° F.; or a stack 125 ft. high when the air temperature is 60° F. and the flue temperature 460°.

LOGARITHMS TO THE BASE 10

	0	1	2	3	4	5	6	7	8	9	10
1.00	0.0000	0004	0009	0013	0017	0022	0026	0030	0035	0039	0043
1.01	0043	0048	0052	0056	0060	0065	0069	0073	0077	0082	0086
1.02	0086	0090	0095	0099	0103	0107	0111	0116	0120	0124	0128
1.03	0128	0133	0137	0141	0145	0149	0154	0158	0162	0166	0170
1.04	0170	0175	0179	0183	0187	0191	0195	0199	0204	0208	0212
1.05	0212	0216	0220	0224	0228	0233	0237	0241	0245	0249	0253
1.06	0253	0257	0261	0265	0269	0273	0278	0282	0286	0290	0294
1.07	0294	0298	0302	0306	0310	0314	0318	0322	0326	0330	0334
1.08	0334	0338	0342	0346	0350	0354	0358	0362	0366	0370	0374
1.09	0374	0378	0382	0386	0390	0394	0398	0402	0406	0410	0414
1.10	0.0414	0418	0422	0426	0430	0434	0438	0441	0445	0449	0453
1.11	0453	0457	0461	0465	0469	0473	0477	0481	0484	0488	0492
1.12	0492	0496	0500	0504	0508	0512	0515	0519	0523	0527	0531
1.13	0531	0535	0538	0542	0546	0550	0554	0558	0561	0565	0569
1.14	0569	0573	0577	0580	0584	0588	0592	0596	0599	0603	0607
1.15	0607	0611	0615	0618	0622	0626	0630	0633	0637	0641	0645
1.16	0645	0648	0652	0656	0660	0663	0667	0671	0674	0678	0682
1.17	0682	0686	0689	0693	0697	0700	0704	0708	0711	0715	0719
1.18	0719	0722	0726	0730	0734	0737	0741	0745	0748	0752	0755
1.19	0755	0759	0763	0766	0770	0774	0777	0781	0785	0788	0792
1.20	0.0792	0795	0799	0803	0806	0810	0813	0817	0821	0824	0828
1.21	0828	0831	0835	0839	0842	0846	0849	0853	0856	0860	0864
1.22	0864	0867	0871	0874	0878	0881	0885	0888	0892	0896	0899
1.23	0899	0903	0906	0910	0913	0917	0920	0924	0927	0931	0934
1.24	0934	0938	0941	0945	0948	0952	0955	0959	0962	0966	0969
1.25	0969	0973	0976	0980	0983	0986	0990	0993	0997	1000	1004
1.26	1004	1007	1011	1014	1017	1021	1024	1028	1031	1035	1038
1.27	1038	1041	1045	1048	1052	1055	1059	1062	1065	1069	1072
1.28	1072	1075	1079	1082	1086	1089	1092	1096	1099	1103	1106
1.29	1106	1109	1113	1116	1119	1123	1126	1129	1133	1136	1139
1.30	0.1139	1143	1146	1149	1153	1156	1159	1163	1166	1169	1173
1.31	1173	1176	1179	1183	1186	1189	1193	1196	1199	1202	1206
1.32	1206	1209	1212	1216	1219	1222	1225	1229	1232	1235	1239
1.33	1239	1242	1245	1248	1252	1255	1258	1261	1265	1268	1271
1.34	1271	1274	1278	1281	1284	1287	1290	1294	1297	1300	1303
1.35	1303	1307	1310	1313	1316	1319	1323	1326	1329	1332	1335
1.36	1335	1339	1342	1345	1348	1351	1355	1358	1361	1364	1367
1.37	1367	1370	1374	1377	1380	1383	1386	1389	1392	1396	1399
1.38	1399	1402	1405	1408	1411	1414	1418	1421	1424	1427	1430
1.39	1430	1433	1436	1440	1443	1446	1449	1452	1455	1458	1461
1.40	0.1461	1464	1467	1471	1474	1477	1480	1483	1486	1489	1492
1.41	1492	1495	1498	1501	1504	1508	1511	1514	1517	1520	1523
1.42	1523	1526	1529	1532	1535	1538	1541	1544	1547	1550	1553
1.43	1553	1556	1559	1562	1565	1569	1572	1575	1578	1581	1584
1.44	1584	1587	1590	1593	1596	1599	1602	1605	1608	1611	1614
1.45	1614	1617	1620	1623	1626	1629	1632	1635	1638	1641	1644
1.46	1644	1647	1649	1652	1655	1658	1661	1664	1667	1670	1673
1.47	1673	1676	1679	1682	1685	1688	1691	1694	1697	1700	1703
1.48	1703	1706	1708	1711	1714	1717	1720	1723	1726	1729	1732
1.49	1732	1735	1738	1741	1744	1746	1749	1752	1755	1758	1761

Logarithms to the Base 10

	0	1	2	3	4	5	6	7	8	9	10
1.50	0.1761	1764	1767	1770	1772	1775	1778	1781	1784	1787	1790
1.51	1790	1793	1796	1798	1801	1804	1807	1810	1813	1816	1818
1.52	1818	1821	1824	1827	1830	1833	1836	1838	1841	1844	1847
1.53	1847	1850	1853	1855	1858	1861	1864	1867	1870	1872	1875
1.54	1875	1878	1881	1884	1886	1889	1892	1895	1898	1901	1903
1.55	1903	1906	1909	1912	1915	1917	1920	1923	1926	1928	1931
1.56	1931	1934	1937	1940	1942	1945	1948	1951	1953	1956	1959
1.57	1959	1962	1965	1967	1970	1973	1976	1978	1981	1984	1987
1.58	1987	1989	1992	1995	1998	2000	2003	2006	2009	2011	2014
1.59	2014	2017	2019	2022	2025	2028	2030	2033	2036	2038	2041
1.60	0.2041	2044	2047	2049	2052	2055	2057	2060	2063	2066	2068
1.61	2068	2071	2074	2076	2079	2082	2084	2087	2090	2092	2095
1.62	2095	2098	2101	2103	2106	2109	2111	2114	2117	2119	2122
1.63	2122	2125	2127	2130	2133	2135	2138	2140	2143	2146	2148
1.64	2148	2151	2154	2156	2159	2162	2164	2167	2170	2172	2175
1.65	2175	2177	2180	2183	2185	2188	2191	2193	2196	2198	2201
1.66	2201	2204	2206	2209	2212	2214	2217	2219	2222	2225	2227
1.67	2227	2230	2232	2235	2238	2240	2243	2245	2248	2251	2253
1.68	2253	2256	2258	2261	2263	2266	2269	2271	2274	2276	2279
1.69	2279	2281	2284	2287	2289	2292	2294	2297	2299	2302	2304
1.70	0.2304	2307	2310	2312	2315	2317	2320	2322	2325	2327	2330
1.71	2330	2333	2335	2338	2340	2343	2345	2348	2350	2353	2355
1.72	2355	2358	2360	2363	2365	2368	2370	2373	2375	2378	2380
1.73	2380	2383	2385	2388	2390	2393	2395	2398	2400	2403	2405
1.74	2405	2408	2410	2413	2415	2418	2420	2423	2425	2428	2430
1.75	2430	2433	2435	2438	2440	2443	2445	2448	2450	2453	2455
1.76	2455	2458	2460	2463	2465	2467	2470	2472	2475	2477	2480
1.77	2480	2482	2485	2487	2490	2492	2494	2497	2499	2502	2504
1.78	2504	2507	2509	2512	2514	2516	2519	2521	2524	2526	2529
1.79	2529	2531	2533	2536	2538	2541	2543	2545	2548	2550	2553
1.80	0.2553	2555	2558	2560	2562	2565	2567	2570	2572	2574	2577
1.81	2577	2579	2582	2584	2586	2589	2591	2594	2596	2598	2601
1.82	2601	2603	2605	2608	2610	2613	2615	2617	2620	2622	2625
1.83	2625	2627	2629	2632	2634	2636	2639	2641	2643	2646	2648
1.84	2648	2651	2653	2655	2658	2660	2662	2665	2667	2669	2672
1.85	2672	2674	2676	2679	2681	2683	2686	2688	2690	2693	2695
1.86	2695	2697	2700	2702	2704	2707	2709	2711	2714	2716	2718
1.87	2718	2721	2723	2725	2728	2730	2732	2735	2737	2739	2742
1.88	2742	2744	2746	2749	2751	2753	2755	2758	2760	2762	2765
1.89	2765	2767	2769	2772	2774	2776	2778	2781	2783	2785	2788
1.90	0.2788	2790	2792	2794	2797	2799	2801	2804	2806	2803	2810
1.91	2810	2813	2815	2817	2819	2822	2824	2826	2828	2831	2833
1.92	2833	2835	2838	2840	2842	2844	2847	2849	2851	2853	2856
1.93	2856	2858	2860	2862	2865	2867	2869	2871	2874	2876	2878
1.94	2878	2880	2882	2885	2887	2889	2891	2894	2896	2898	2900
1.95	2900	2903	2905	2907	2909	2911	2914	2916	2918	2920	2923
1.96	2923	2925	2927	2929	2931	2934	2936	2938	2940	2942	2945
1.97	2945	2947	2949	2951	2953	2956	2958	2960	2962	2964	2967
1.98	2967	2969	2971	2973	2975	2978	2980	2982	2984	2986	2989
1.99	2989	2991	2993	2995	2997	2999	3002	3004	3006	3008	3010

Logarithms to the Base 10

These two pages give the common logarithms of numbers between 1 and 10, correct to four places. Moving the decimal point n places to the right (or left) in the number is equivalent to adding n (or $-n$) to the logarithm. Thus, log $0.017453 = 0.2419 - 2$ [$=\bar{2}.2419$].

To facilitate interpolation, the tenths of the tabular differences are given at the end of each line, so that the differences themselves need not be considered. In using these aids, first find the nearest tabular entry, and then add (to move to the right) or subtract (to move to the left), as the case may require.

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	0	1	2	3	4	5	6	7	8	9	10	Tenths of the Tabular Difference 1	2	3	4	5
1.0	0.0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	0414					
1.1	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	0792					
1.2	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	1139					
1.3	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	1461					
1.4	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	1761					
1.5	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	2041					
1.6	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	2304					
1.7	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2553					
1.8	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2788					
1.9	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	3010					
2.0	0.3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	3222	2	4	6	8	11
2.1	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	3424	2	4	6	8	10
2.2	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	3617	2	4	6	8	10
2.3	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	3802	2	4	5	7	9
2.4	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	3979	2	4	5	7	9
2.5	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	4150	2	3	5	7	9
2.6	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	4314	2	3	5	7	8
2.7	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	4472	2	3	5	6	8
2.8	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	4624	2	3	5	6	8
2.9	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	4771	1	3	4	6	7
3.0	0.4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	4914	1	3	4	6	7
3.1	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	5051	1	3	4	6	7
3.2	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	5185	1	3	4	5	7
3.3	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	5315	1	3	4	5	6
3.4	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	5441	1	3	4	5	6
3.5	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	5563	1	2	4	5	6
3.6	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	5682	1	2	4	5	6
3.7	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	5798	1	2	3	5	6
3.8	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	5911	1	2	3	5	6
3.9	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	6021	1	2	3	4	6
4.0	0.6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	6128	1	2	3	4	5
4.1	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	6232	1	2	3	4	5
4.2	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	6335	1	2	3	4	5
4.3	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	6435	1	2	3	4	5
4.4	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	6532	1	2	3	4	5
4.5	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	6628	1	2	3	4	5
4.6	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	6721	1	2	3	4	5
4.7	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	6812	1	2	3	4	5
4.8	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	6902	1	2	3	4	4
4.9	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	6990	1	2	3	4	4

To avoid interpolation in the first ten lines, use the special table on the preceding page.

Logarithms to the Base 10

	0	1	2	3	4	5	6	7	8	9	10	Tenths of the Tabular Difference 1	2	3	4	5
5.0	0.6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	7076	1	2	3	3	4
5.1	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	7160	1	2	3	3	4
5.2	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	7243	1	2	2	3	4
5.3	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	7324	1	2	2	3	4
5.4	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	7404	1	2	2	3	4
5.5	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	7482	1	2	2	3	4
5.6	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	7559	1	2	2	3	4
5.7	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	7634	1	2	2	3	4
5.8	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	7709	1	1	2	3	4
5.9	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	7782	1	1	2	3	4
6.0	0.7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	7853	1	1	2	3	4
6.1	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	7924	1	1	2	3	4
6.2	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	7993	1	1	2	3	3
6.3	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	8062	1	1	2	3	3
6.4	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	8129	1	1	2	3	3
6.5	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	8195	1	1	2	3	3
6.6	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	8261	1	1	2	3	3
6.7	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	8325	1	1	2	3	3
6.8	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	8388	1	1	2	3	3
6.9	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	8451	1	1	2	3	3
7.0	0.8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	8513	1	1	2	2	3
7.1	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	8573	1	1	2	2	3
7.2	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	8633	1	1	2	2	3
7.3	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	8692	1	1	2	2	3
7.4	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	8751	1	1	2	2	3
7.5	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	8808	1	1	2	2	3
7.6	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	8865	1	1	2	2	3
7.7	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	8921	1	1	2	2	3
7.8	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	8976	1	1	2	2	3
7.9	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	9031	1	1	2	2	3
8.0	0.9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	9085	1	1	2	2	3
8.1	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	9138	1	1	2	2	3
8.2	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	9191	1	1	2	2	3
8.3	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	9243	1	1	2	2	3
8.4	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	9294	1	1	2	2	3
8.5	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	9345	1	1	2	2	3
8.6	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	9395	1	1	2	2	3
8.7	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	9445	0	1	1	2	2
8.8	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	9494	0	1	1	2	2
8.9	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	9542	0	1	1	2	2
9.0	0.9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	9590	0	1	1	2	2
9.1	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	9638	0	1	1	2	2
9.2	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	9685	0	1	1	2	2
9.3	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	9731	0	1	1	2	2
9.4	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	9777	0	1	1	2	2
9.5	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	9823	0	1	1	2	2
9.6	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	9868	0	1	1	2	2
9.7	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	9912	0	1	1	2	2
9.8	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	9956	0	1	1	2	2
9.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9983	9987	9991	9996	[illegible]	0	1	1	2	2

Logarithms to the Base e

These two pages give the natural (hyperbolic, or Napierian) logarithms of numbers between 1 and 10, correct to four places. Moving the decimal point n places to the right (or left) in the number is equivalent to adding n times 2.3026 (or n times $\bar{3}.6974$) to the logarithm.

1	2.3026	1	0.6974 − 3
2	4.6052	2	0.3948 − 5
3	6.9078	3	0.0922 − 7
4	9.2103	4	0.7897 − 10
5	11.5129	5	0.4871 − 12
6	13.8155	6	0.1845 − 14
7	16.1181	7	0.8819 − 17
8	18.4207	8	0.5793 − 19
9	20.7233	9	0.2767 − 21

$\log_e$ (Base e = 2.71828 +)

												Tenths of the Tabular Difference				
	0	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5
1.0	0.0000	0100	0198	0296	0392	0488	0583	0677	0770	0862	0.0953	10	19	29	38	48
1.1	0953	1044	1133	1222	1310	1398	1484	1570	1655	1740	1823	9	17	26	35	44
1.2	1823	1906	1989	2070	2151	2231	2311	2390	2469	2546	2624	8	16	24	32	40
1.3	2624	2700	2776	2852	2927	3001	3075	3148	3221	3293	3365	7	15	22	30	37
1.4	3365	3436	3507	3577	3646	3716	3784	3853	3920	3988	4055	7	14	21	28	34
1.5	4055	4121	4187	4253	4318	4383	4447	4511	4574	4637	4700	6	13	19	26	32
1.6	4700	4762	4824	4886	4947	5008	5068	5128	5188	5247	5306	6	12	18	24	30
1.7	5306	5365	5423	5481	5539	5596	5653	5710	5766	5822	5878	6	11	17	23	29
1.8	5878	5933	5988	6043	6098	6152	6206	6259	6313	6366	6419	5	11	16	22	27
1.9	6419	6471	6523	6575	6627	6678	6729	6780	6831	6881	0.6931	5	10	15	21	26
2.0	0.6931	6981	7031	7080	7129	7178	7227	7275	7324	7372	7419	5	10	15	20	24
2.1	7419	7467	7514	7561	7608	7655	7701	7747	7793	7839	7885	5	9	14	19	23
2.2	7885	7930	7975	8020	8065	8109	8154	8198	8242	8286	8329	4	9	13	18	22
2.3	8329	8372	8416	8459	8502	8544	8587	8629	8671	8713	8755	4	9	13	17	21
2.4	8755	8796	8838	8879	8920	8961	9002	9042	9083	9123	9163	4	8	12	16	20
2.5	9163	9203	9243	9282	9322	9361	9400	9439	9478	9517	9555	4	8	12	16	20
2.6	9555	9594	9632	9670	9708	9746	9783	9821	9858	9895	0.9933	4	8	11	15	19
2.7	0.9933	9969	0006	0043	0080	0116	0152	0188	0225	0260	1.0296	4	7	11	15	18
2.8	1.0296	0332	0367	0403	0438	0473	0508	0543	0578	0613	0647	4	7	11	14	18
2.9	0647	0682	0716	0750	0784	0818	0852	0886	0919	0953	1.0986	3	7	10	14	17
3.0	1.0986	1019	1053	1086	1119	1151	1184	1217	1249	1282	1314	3	7	10	13	16
3.1	1314	1346	1378	1410	1442	1474	1506	1537	1569	1600	1632	3	6	10	13	16
3.2	1632	1663	1694	1725	1756	1787	1817	1848	1878	1909	1939	3	6	9	12	15
3.3	1939	1969	2000	2030	2060	2090	2119	2149	2179	2208	2238	3	6	9	12	15
3.4	2238	2267	2296	2326	2355	2384	2413	2442	2470	2499	2528	3	6	9	12	14
3.5	2528	2556	2585	2613	2641	2669	2698	2726	2754	2782	2809	3	6	8	11	14
3.6	2809	2837	2865	2892	2920	2947	2975	3002	3029	3056	3083	3	5	8	11	14
3.7	3083	3110	3137	3164	3191	3218	3244	3271	3297	3324	3350	3	5	8	11	13
3.8	3350	3376	3403	3429	3455	3481	3507	3533	3558	3584	3610	3	5	8	10	13
3.9	3610	3635	3661	3686	3712	3737	3762	3788	3813	3838	1.3863	3	5	8	10	13
4.0	1.3863	3888	3913	3938	3962	3987	4012	4036	4061	4085	4110	2	5	7	10	12
4.1	4110	4134	4159	4183	4207	4231	4255	4279	4303	4327	4351	2	5	7	10	12
4.2	4351	4375	4398	4422	4446	4469	4493	4516	4540	4563	4586	2	5	7	9	12
4.3	4586	4609	4633	4656	4679	4702	4725	4748	4770	4793	4816	2	5	7	9	11
4.4	4816	4839	4861	4884	4907	4929	4951	4974	4996	5019	5041	2	4	7	9	11
4.5	5041	5063	5085	5107	5129	5151	5173	5195	5217	5239	5261	2	4	7	9	11
4.6	5261	5282	5304	5326	5347	5369	5390	5412	5433	5454	5476	2	4	6	9	11
4.7	5476	5497	5518	5539	5560	5581	5602	5623	5644	5665	5686	2	4	6	8	11
4.8	5686	5707	5728	5748	5769	5790	5810	5831	5851	5872	5892	2	4	6	8	10
4.9	5892	5913	5933	5953	5974	5994	6014	6034	6054	6074	1.6094	2	4	6	8	10

Logarithms to the Base e

												Tenths of the Tabular Difference				
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**
5.0	1.6094	6114	6134	6154	6174	6194	6214	6233	6253	6273	6292	2	4	6	8	10
5.1	6292	6312	6332	6351	6371	6390	6409	6429	6448	6467	6487	2	4	6	8	10
5.2	6487	6506	6525	6544	6563	6582	6601	6620	6639	6658	6677	2	4	6	8	10
5.3	6677	6696	6715	6734	6752	6771	6790	6808	6827	6845	6864	2	4	6	7	9
5.4	6864	6882	6901	6919	6938	6956	6974	6993	7011	7029	7047	2	4	6	7	9
5.5	7047	7066	7084	7102	7120	7138	7156	7174	7192	7210	7228	2	4	5	7	9
5.6	7228	7246	7263	7281	7299	7317	7334	7352	7370	7387	7405	2	4	5	7	9
5.7	7405	7422	7440	7457	7475	7492	7509	7527	7544	7561	7579	2	3	5	7	9
5.8	7579	7596	7613	7630	7647	7664	7681	7699	7716	7733	7750	2	3	5	7	9
5.9	7750	7766	7783	7800	7817	7834	7851	7867	7884	7901	1.7918	2	3	5	7	8
6.0	1.7918	7934	7951	7967	7984	8001	8017	8034	8050	8066	8083	2	3	5	7	8
6.1	8083	8099	8116	8132	8148	8165	8181	8197	8213	8229	8245	2	3	5	7	8
6.2	8245	8262	8278	8294	8310	8326	8342	8358	8374	8390	8405	2	3	5	6	8
6.3	8405	8421	8437	8453	8469	8485	8500	8516	8532	8547	8563	2	3	5	6	8
6.4	8563	8579	8594	8610	8625	8641	8656	8672	8687	8703	8718	2	3	5	6	8
6.5	8718	8733	8749	8764	8779	8795	8810	8825	8840	8856	8871	2	3	5	6	8
6.6	8871	8886	8901	8916	8931	8946	8961	8976	8991	9006	9021	2	3	5	6	8
6.7	9021	9036	9051	9066	9081	9095	9110	9125	9140	9155	9169	1	3	4	6	7
6.8	9169	9184	9199	9213	9228	9242	9257	9272	9286	9301	9315	1	3	4	6	7
6.9	9315	9330	9344	9359	9373	9387	9402	9416	9430	9445	1.9459	1	3	4	6	7
7.0	1.9459	9473	9488	9502	9516	9530	9544	9559	9573	9587	9601	1	3	4	6	7
7.1	9601	9615	9629	9643	9657	9671	9685	9699	9713	9727	9741	1	3	4	6	7
7.2	9741	9755	9769	9782	9796	9810	9824	9838	9851	9865	1.9879	1	3	4	6	7
7.3	1.9879	9892	9906	9920	9933	9947	9961	9974	9988	0001	2.0015	1	3	4	5	7
7.4	2.0015	0028	0042	0055	0069	0082	0096	0109	0122	0136	0149	1	3	4	5	7
7.5	0149	0162	0176	0189	0202	0215	0229	0242	0255	0268	0281	1	3	4	5	7
7.6	0281	0295	0308	0321	0334	0347	0360	0373	0386	0399	0412	1	3	4	5	7
7.7	0412	0425	0438	0451	0464	0477	0490	0503	0516	0528	0541	1	3	4	5	6
7.8	0541	0554	0567	0580	0592	0605	0618	0631	0643	0656	0669	1	3	4	5	6
7.9	0669	0681	0694	0707	0719	0732	0744	0757	0769	0782	2.0794	1	3	4	5	6
8.0	2.0794	0807	0819	0832	0844	0857	0869	0882	0894	0906	0919	1	2	4	5	6
8.1	0919	0931	0943	0956	0968	0980	0992	1005	1017	1029	1041	1	2	4	5	6
8.2	1041	1054	1066	1078	1090	1102	1114	1126	1138	1150	1163	1	2	4	5	6
8.3	1163	1175	1187	1199	1211	1223	1235	1247	1258	1270	1282	1	2	4	5	6
8.4	1282	1294	1306	1318	1330	1342	1353	1365	1377	1389	1401	1	2	4	5	6
8.5	1401	1412	1424	1436	1448	1459	1471	1483	1494	1506	1518	1	2	4	5	6
8.6	1518	1529	1541	1552	1564	1576	1587	1599	1610	1622	1633	1	2	3	5	6
8.7	1633	1645	1656	1668	1679	1691	1702	1713	1725	1736	1748	1	2	3	5	6
8.8	1748	1759	1770	1782	1793	1804	1815	1827	1838	1849	1861	1	2	3	5	6
8.9	1861	1872	1883	1894	1905	1917	1928	1939	1950	1961	2.1972	1	2	3	4	6
9.0	2.1972	1983	1994	2006	2017	2028	2039	2050	2061	2072	2083	1	2	3	4	6
9.1	2083	2094	2105	2116	2127	2138	2148	2159	2170	2181	2192	1	2	3	4	5
9.2	2192	2203	2214	2225	2235	2246	2257	2268	2279	2289	2300	1	2	3	4	5
9.3	2300	2311	2322	2332	2343	2354	2364	2375	2386	2396	2407	1	2	3	4	5
9.4	2407	2418	2428	2439	2450	2460	2471	2481	2492	2502	2513	1	2	3	4	5
9.5	2513	2523	2534	2544	2555	2565	2576	2586	2597	2607	2618	1	2	3	4	5
9.6	2618	2628	2638	2649	2659	2670	2680	2690	2701	2711	2721	1	2	3	4	5
9.7	2721	2732	2742	2752	2762	2773	2783	2793	2803	2814	2824	1	2	3	4	5
9.8	2824	2834	2844	2854	2865	2875	2885	2895	2905	2915	2925	1	2	3	4	5
9.9	2925	2935	2946	2956	2966	2976	2986	2996	3006	3016	2.3026	1	2	3	4	5

PART II

CHARTS

CONSTRUCTION AND USE OF DIAGRAMS

Chart 1. This chart gives the work required to compress and deliver a cubic foot of (sup.pr.) air, or the horse-power to compress and deliver 1000 cu. ft. of (sup.pr.) air per minute, if the ratio of pressure (del.pr.) ÷ (sup.pr.), the value of s and the (sup.pr.) are known, and compression occurs *in one stage.* The work or H.P. for any number of cubic feet is directly proportional to number of feet. The curves are dependent upon the formulas, Eq. (31), for the case when $s=1$, and Eq. (49) for the case when s is not equal to 1. They were drawn as follows:

On a horizontal base various values of R_p are laid off, starting with the value 2 at the origin. The values for work were then found for a number of values of R_p with a constant value of (sup.pr.) and s. A vertical work scale was then laid off from origin of R_p and a curve drawn through the points found by the intersection of horizontal lines through values of work, with vertical lines through corresponding values of R_p. The process was then repeated for other values of s and curves similar to the first, drawn for the other values of s. From the construction so far completed it is possible to find the work per cubic foot for any pressure ratio and any value of s for *one* (sup.pr.) by projecting up from the proper value of R_p to the curve of value of s and then horizontally to the scale of work. It will be noted from these formulas, however, that the work may be laid off on the horizontal base and a group of lines drawn so that the slope of the line equals ratio of work for any supply pressure to that for the (sup.pr.) originally used. For convenience, in order that the group of s curves and the latter group may be as distinct as possible, the origin of the latter group is taken at the opposite end of the base line. If from the point for work originally found, a projection is made horizontally to the proper (sup.pr.) curve, the value for work with this (sup.pr.) will be found directly below. It will be noted that from point of intersection of the vertical from the R_p value with the s curve, it is only necessary to project horizontally far enough to intersect the desired (sup.pr.) curve, and since no information of value will be found by continuing to the work scale for the original (sup.pr.) this is omitted from the diagram.

In brief, then, the use of this chart consists in projecting upward from the proper value of R_p to the proper s curve, then passing horizontally to the value of (sup.pr.) and finally downward to the work scale. As an example of the use of the curve: Find the work to compress 1000 cu. ft. of free air from 1 to $8\frac{1}{2}$

atmospheres adiabatically. On the curve project upward from $R_p = 8.5$ to curve of $s = 1.406$, then over to 14.7 (sup.pr.) curve and down to read work $= 6,300,000$.

Chart 2. This gives the work required to compress and deliver a cubic foot of (sup.pr.) air or the horse-power to compress and deliver 1000 cu. ft. of (sup.pr.) air per minute if the ratio of pressures, the value of s and (sup.pr.) are known and if compression occurs *in two stages* with best-receiver pressure and perfect intercooling. The work or H.P. for any other number of cubic feet may be found by multiplying work per foot by the number of feet. The method of arriving at this chart was exactly the same as that for one stage.

As an example of the use of the chart, find the work to compress 5 cu. ft. of free air from 1 to $8\frac{1}{2}$ atmospheres adiabatically in two stages. Project upward from $R_p = 8.5$ to curve $s = 1.406$, then over to 14.7 curve and down to read 5320 ft.-lbs. per cubic foot.

Chart 3. This chart gives the work necessary to compress and deliver a cubic foot of (sup.pr.) air, or horse-power to compress and deliver 1000 cu. ft. of (sup. pr.) air per minute, if the ratio of pressures, the value of s, and the (sup. pr.) are known and if the compression occurs *in three stages* with best-receiver pressures and perfect intercooling. The work or horse-power for any other number of cubic feet may be found by multiplying the work for one foot by the number of feet.

As an example of use of this chart, determine the horse-power to compress 100 cu. ft. free air per minute adiabatically in three stages from 15 lbs. per square inch abs. to 90 lbs. per square inch gage. From $R_p = 7$, project to curve of $s = 1.4$ then over to (sup.pr.) = 15 and down, and the horse-power will be found to be 13.6.

Chart 4. This chart is for finding the (m.e.p.) of compressors. In the case of multi-stage compressors with best-receiver pressure and perfect intercooling, the (m.e.p.) of each cylinder may be found by considering each cylinder as a single-stage compressor; or the (m.e.p.) of the compressor referred to the L.P. cylinder may be found.

The chart depends on the fact that the work per cubic foot of (sup.pr.) gas is equal to the (m.e.p.) for the no-clearance case and that the (m.e.p.) with clearance is equal to the (m.e.p.) for no clearance, times the volumetric efficiency. Diagrams 1, 2 and 4 are reproductions of Charts 2, 3 and 4 to a smaller scale and hence need no explanation as to derivation. Their use may be briefly shown. From the given ratio of pressures project upward to the proper curve, then horizontally to the (sup.pr.) and downward to read work per cubic feet of (sup.pr.) gas.

The volumetric efficiency diagram was drawn in the following manner: From Eq. (59) vol. eff. $= (1 + c - cR_p^{\frac{1}{s}})$, showing that it depends upon three variables, R_p, c and s. A horizontal scale of values of R_p was laid off. Values of $R_p^{\frac{1}{s}}$ were found and a vertical scale of this quantity laid off from the same origin as the R_p values. Through the intersection of the verticals from various

values of R_p with the horizontals drawn through the corresponding values of $(R_p)^{\frac{1}{s}}$ for a known value of s, a curve of this value of s was drawn. In a similar way curves of other values of s were drawn. From the construction so far completed it is possible to find the value of $(R_p)^{\frac{1}{s}}$ by projecting upward from any value of R_p to the curve of s and then horizontally to the scale of $(R_p)^{\frac{1}{s}}$. Values of volumetric efficiencies found for various clearances and the values of $(R_p)^{\frac{1}{s}}$ are laid off on a horizontal base, with the origin at the opposite end of scale from that of R_p values, in order that clearance curves and s curves might be as distinct as possible. These clearance curves were drawn through the intersection of horizontals through the $(R_p)^{\frac{1}{s}}$ values, and of verticals through the vulmetric efficiency values corresponding to them for the particular clearance in question.

To find volumetric efficiency then it is merely necessary to project from value of R_p to the proper s curve, then across to the given clearance and finally down to volumetric efficiency. As the value of $(R_p)^{\frac{1}{s}}$ is not desired, the horizontal projection is carried only to the intersection with the clearance curve and not to the edge of the diagram. To find the (m.e.p.) for single stage, the work per cubic foot is found from the diagram and then the volumetric efficiency, both as described above. *The product is (m.e.p.).*

For multi-stage compressors with perfect intercooling and best-receiver pressure, as stated above, the (m.e.p.) of each cylinder may be found, considering each to be a single-stage compressor and remembering that (1 rec.pr.) becomes (sup.pr.) for second stage, and (del.pr.) for first stage; and that (2 rec. pr.) becomes (sup.pr.) for third stage, (del.pr.) for second stage. The (m.e.p.) reduced to low-pressure cylinder is found by taking work per cubic foot of (sup.pr.) gas and multiplying by volumetric efficiency of low-pressure cylinder.

To illustrate the use of this curve solve the following problem. A three-stage air compressor runs at 100 R.P.M. with best receiver pressure; the low-pressure cylinder is 32 × 24 ins., clearance 5 per cent. Compression from atmosphere to 140 lbs. per square inch absolute, $s=1.4$. Find horse-power and the best receiver pressures.

Projecting upward from the pressure ratio of 9.35 to the line of $s=1.4$ and then over to (sup.pr.) = 15 in diagram 4, since compression is three stage and from 15 lbs. per square inch to 140 lbs. per square inch, work per cubic foot or (m.e.p.), is found for no clearance to be 37.8 abs. per square inch; since best-receiver pressure assumed is 31.6, which gives a ratio of 2.1 for the low-pressure cylinder. From diagram 3, by projecting upward from $R_p=2.1$ and over to the 5 per cent clearance line, volumetric efficiency is 96.5. The product gives (m.e.p.) reduced to low-pressure cylinder and is 36.5. From the $\frac{(\text{m.e.p.})\,Lan}{33{,}000}$ formula, the horse-power is found to be 358.

Chart 5. There is one (sup.pr.), which for a definite (del.pr.) will give the maximum work of compression. This chart, originated by Mr. T. M. Gunn,

gives a graphical means of finding this value of (sup.pr.) when the (del.pr.), clearance and value of s are known. It also gives on the right-hand of the chart a means for finding the (m.e.p.) for this condition. The figure was drawn by means of Eqs. (139) and (142).

To find the (sup.pr.) to give maximum work for any (del.pr.) it is only necessary to project from the proper value of s to the given clearance curve, and then horizontally to read the value of R_p. The (del.pr.) divided by this gives the (sup.pr.) desired. To obtain the (m.e.p.) project upward from the value of s to the clearance curve, then horizontally to read the ratio $\left(\frac{\text{m.e.p.}}{\text{del.pr.}}\right)$. *The (del.pr.) multiplied by this quantity gives the m.e.p.*

As an example of the use of this chart let it be required to find the (sup.pr.) for the case of maximum work for 9 × 12 in. double-acting compressor running 200 R.P.M., having 5 per cent clearance and delivering against 45 lbs. per square inch gage.; also the horse-power. Compression such that $s=1.3$.

Projecting from the value 1.3 for s on the left-hand diagram to the line of 5 per cent clearance find R_p to be 2.8, hence (sup.pr.) $=\frac{60}{2.8}=21.4$ lbs. per square inch absolute $=6.4$ lbs. per square inch gage. Again, projecting from value 1.3 for s on right-hand diagram to line of 5 per cent clearance find that $\frac{(\text{m.e.p.})}{(\text{del.pr.})}=.383$, hence (m.e.p.). $=23$ and I.H.P. $=\frac{23 \times 1 \times 64 \times 400}{33{,}000}$ $=17.8$.

Chart 6. This chart is designed to show the saving in work done in compressing and delivering gases by two-stage or three-stage compression with best-receiver pressure and perfect intercooling over that required for compressing and delivering the same gas between the same pressures in one stage. The chart was made by laying off on a horizontal base a scale of pressure ratios. From the same origin a scale of work for two or three stage divided by the work of one stage was drawn vertically. For a number of values of R_p the work to compress a cubic foot of gas was found for one, two and three stage for each value of s. The values found by dividing the work of two or three stage by the work of single stage were plotted above the proper R_p values, and opposite the proper ratio, values and curves drawn through all points for one value of s. To find the saving by compressing in two or three stages project from the proper R_p value to the chosen s curve for the desired number of stages, then horizontally to read the ratio of multi-stage to one-stage work. This value gives per cent power needed for one stage that will be required to compress the same gas multi-stage. Saving by multi-stage as a percentage of single stage is one minus the value read.

To illustrate the use of this chart, find the per cent of work needed to compress a cubic foot of air adiabatically from 1 to $8\frac{1}{2}$ atmospheres in two stages compared to doing it in one stage. From examples under charts Nos. 1 and 2 it was found that work per cubic foot was 6300 ft.-lbs. and 5320 ft.-lbs. respectively, for one- and two-stage compression, or that two stage was 84.5 per cent

of one stage. From R_p, $8\frac{1}{2}$ project up on Chart 6 to $s=1.406$ for two stage, and over to read 84.6 per cent, which is nearly the same.

Chart 7. This chart, designed by Mr. T. M. Gunn, shows the economy compared to isothermal compression.

The chart was drawn on the basis of the following equation:

$$\text{Economy (isothermal)} = \frac{\text{m.e.p. isothermal (no clearance)}}{\text{m.e.p. actual} \div E_v \text{ actual}}$$

Values of this expression were worked out for each exponent, for assumed values of R_p. A scale of values of R_p was laid off horizontally and from the same origin a vertical scale of values of the ratio of isothermal to adiabatic. The results found were then plotted, each point above its proper R_p and opposite its ratio value. Curves were then drawn through all the points found for the same value of s. In a similar way a set of curves for two-stage and a set for three-stage compression were drawn.

This chart is also useful in obtaining the (m.e.p.) of the cycle if the (sup.pr.) and the volumetric efficiency of the cylinder be known. A second horizontal scale laid off above the R_p scale shows the (m.e.p.) per pound of (sup.pr. for) the isothermal no-clearance cycle. This is found to be equal to $\log_e R_p$, since the (m.e.p.) for no clearance is equal to the work per cubic foot of (sup.pr.) gas, which, in turn, for the isothermal case is (sup.pr.) $\log_e R_p$ or $\log_e R_p$ when (sup.pr.) $=1$.

Knowing the ratio of pressures, economy compared to isothermal can be found as explained above. Also knowing R_p the (m.e.p.) per pound initial is found from the upper scale.

Since the latter quantity is assumed to be known, by multiplying it by factor just found there is obtained (m.e.p.) isothermal. Since volumetric efficiency is assumed known, all the factors are known for the first equation given above which, rearranged, reads

$$\text{(m.e.p.) actual} = \frac{\text{m.e.p. isothermal (no clearance)}}{\text{(economy isothermal)} \div E_v},$$

Chart 8. This chart is drawn to give the cylinder displacement for a desired capacity, with various values of R_p, s and clearance. From the formula Eq. (58): (L.P. Cap.) $=D(1+c-cR_p^{\frac{1}{s}})$.

The right-hand portion of the diagram is for the purpose of finding values of $(R_p)^{\frac{1}{s}}$ for various values of R_p and s, and is constructed as in Chart 2. The values of the lower scale on the left-hand diagram give values of $D=$ (L. P. Cap.) $\div(1+c-cR_p^{\frac{1}{s}})$, where capacity is taken at 100 cu.ft., this scale was laid out and the clearance curves points found by solving the above equation for various values of $(R_p)^{\frac{1}{s}}$ for each value of c. To obtain the displacement necessary for a certain capacity with a given value of R_p, c and s, project upward from R_p to the proper s curve across to the c curve and down to read displacement per hundred cubic feet. Also on the left-hand diagram are drawn lines of piston speed, and on left-hand edge a scale of cylinder areas and diameters to give displacements found on horizontal scale. To obtain cylinder areas or *approximate* diameters in inches project from displacement to piston speed line

and across to read cylinder area or diameter. Figures given are for 100 cu.ft. per minute. For any other volume the displacement and area of cylinder will be as desired volume to 100, and diameters will be as $\sqrt{\text{desired volume to 100}}$.

As an example of the use of Chart 8, let it be required to find the low-pressure cylinder size for a compressor to handle 1500 cu. ft. of free air per minute. Receiver pressure to be 45 lbs. per square inch gage and (sup.pr.) to be atmosphere. Piston speed limited to 500 ft. per minute. Compression to be so that $s=1.4$ and clearance $=4$ per cent. Projecting upward from $R_p=4$ to $s=1.4$, across to $c=4\%$, and down to piston speed $=500$, find the diameter of a cylinder for 100 cu. ft. per minute is 6.3. For 1500 cu. ft. the diameter will be as $\sqrt{15}\times 6.3=3.9\times 6.3=24$ ins.

Chart 9. This diagram for mean effective pressure in terms of initial and back pressure, clearance, compression and cut-off, facilitates the solution of Eq. (184). The mean effective pressure is the difference between mean forward and mean back pressure. The former is dependent upon clearance, cut-off and initial pressure. In the example shown on the figure by letters and dotted lines, clearance is assumed 5 per cent, shown at A. Project horizontally to the point F, on the contour line for the assumed cut-off, 12 per cent. Project downward to the logarithmic scale for "mean forward pressure in terms of initial pressure" to the point G. On the scale for "initial pressure" find the point H, representing the assumed initial pressure, 115 lbs. absolute. Through G and H a straight line is passed to the point K on the scale for "mean forward pressure," where the value is read, m.f.p. $=49.5$ lbs. absolute.

Mean back pressure is similarly dependent upon clearance, compression and back pressure, and the same process is followed out by the points, A, B, C, D and E, reading the mean back pressure, 3.2 lbs. absolute at the point E. Then by subtraction (m.e.p.) = (m.f.p.) − (m.b.p.) $=49.5-3.2=46.3$ lbs.

Chart 10 is arranged to show what conditions must be fulfilled in order to obtain equal work with *complete expansion in both cylinders* in a compound engine, finite receiver, logarithmic law, no clearance, when low-pressure admission and high-pressure exhaust are not simultaneous. The diagram represents graphically the conditions expressed in Eqs. (283) to (286).

To illustrate its use assume that in an engine operating on such a cycle, the volume of receiver is 1.5 times the high-pressure displacement, $1.5=y$, then $\frac{1}{y}=.667$. Locate the point A on the scale at bottom of diagram, corresponding to this value. Project upward to the curve marked "ratio of cut-offs" and at the side, C, read ratio of cut-offs $Z_H/Z_L=.572$. Next extending the line AB to its intersection D, with the curve GH, the point D is found. From D project horizontally to the contour line representing the given ratio of initial to back pressure. In this case, initial pressure is assumed ten times back pressure. Thus the point E is located. Directly above E at the top of the sheet is read the cylinder ratio, at F. $R_C=D_L/D_H=2.4$.

If cylinder ratio and initial and final pressures are the fundamental data of the problem, the ratio of cut-offs and ratio of high-pressure displacements to receiver volume may be found by reversing the order.

Chart 12. Diagram (A) is the Marks and Davis modification of the C_p curve of Knobloch and Jacobs, the integral of which (C) gives the heat of superheat from any temperature of steam generation to actual steam temperature, while (B) shows the values for the mean specific heat above the temperature of saturation for the particular pressure in question.

Chart 13. This diagram is for the purpose of finding the cubic feet per pound, or pounds per cubic foot, of a gas at 32° F. and a pressure of 29.92 ins. of Hg, if its volume or weight per cubic foot be known at any pressure and temperature. The curves depend upon the fact that the pounds per cubic foot (δ) vary directly as the pressure and inversely as the temperature. That is $\delta_{32°,\ 29.92''} = \delta_{\ TP} \dfrac{T}{492} \dfrac{29.92}{P}$. The line of least slope is so drawn that for any temperature on the horizontal scale its value when divided by 492 may be read on the vertical scale. The group of lines with the greater slope is so drawn that for any value on the vertical scale this quantity times $29.92/P$ may be used on the horizontal scale. That is, the vertical scale gives the ratio of densities as affected by temperature for constant pressure, while horizontal scale gives the ratio as affected by both temperature and pressure. A reciprocal scale is given in each case for volume calculations.

To find the pounds per cubic foot of gas at 32° F. and 29.92 ins. of mercury when its value is known for 90° and 13 lbs. per square inch. On the temperature scale, pass vertically until the temperature line is reached, then horizontally until the curve for 13 lbs. absolute is reached. The value on the scale below is found to be 1.265, so that the density under the standard conditions is 1.265 of the value under known conditions. Had it been required to find the cubic feet per pound the process would be precisely the same, the value being taken from the lower scale, which for the example reads .79, or, the cubic feet per pound under standard conditions is 79 per cent of the value under conditions assumed.

Charts 16 to 21. These are diagrams of the properties of steam and give respectively the pressure-temperature values, heat of the liquid, latent heat, total heat, specific volume and density of the liquid, and specific volume and density of the vapor. The values in the charts correspond to the tabular values given in the steam table (XL).

Charts 25 and 26. These diagrams, devised by Professor Parr were derived from Eq. (576), $h = h' - 0.000367h_b(t_d - t_w)\left(1 - \dfrac{t_w - 32}{1571}\right)$, where h_b is barometric height in inches, after applying all corrections, and h' is pressure of saturated water vapor, in inches of mercury, corresponding to the temperature t_w. The vapor pressure, h, is in ins. of mercury corresponding to given readings of the wet- and dry-bulb thermometers, t_d and t_w, degrees F. The use of the curves is best illustrated by an example: if the dry-bulb reading is 75° F. and the wet-bulb 65° F., find the dew point. The difference of wet- and dry-bulb temperatures is 10°. From 10° at the top of the diagram (B) Chart 25 project downward, and from 75° air temperature at the left of diagram project

to the right to the intersection, where the dew point is read by interpolation between the contour curves at (*C*) to be 59.5° F. These curves are drawn for a barometric pressure of 29.92 ins. (standard) and will not apply correctly, when the barometer is not equal to this, though with fair approximation, so long as the difference in barometer is not great. Where there is much departure the formula must be used. Chart 26 gives weight of aqueous vapor per cubic foot of mixture, in grains ($\frac{1}{7000}$ lb.) and also the degree of humidity. The temperature of the dew point 59.6° F., is located at (*C'*) on the right-hand side. Interpolation between the ends of the contours for weight, gives 5.6 grains per cubic foot. On the same scale the temperature of the air, F., is represented at point (*A*) 75°, projecting to the intersecting point *D* and down to the bottom of the diagram gives on the scale for degree of humidity, 60 per cent.

Charts 27, 28 and 29. These diagrams have been plotted chiefly from experimental data: the lower values are new, but the upper are those given by Starr several years ago and generally accepted by refrigeration engineers, as standard.

These data refer to the equilibrium conditions of the solution, and in using them for practical problems care must be taken to avoid applying them to other conditions, for example to solutions that are not homogeneous, or in which there has not been sufficient time for the establishment of equilibrium.

Charts 30 and 31. These represent various fractionation tests plotted in curve form, on which are indicated the boiling-points of known hydrocarbons, and bands are added for the class of distillate in accordance with the Robinson classification. Horizontal distances represent fractions distilled, a fraction being the per cent by volume that has been discharged between two given temperatures in a boiling mass, the temperature continually rising. Incidentally it may be noted that the temperature is different in the vapor than in the boiling liquid, though that of the liquid is usually taken. The rate of boiling or application of heat very seriously affects these curves, any one of which might easily be changed thereby.

Chart 33. This diagram gives the heats of reaction plotted as a function of *S* alone, laid off horizontally, and a separate curve drawn for each value of the $\frac{CO}{CO_2}$ ratio, 2, 6, 15 and infinity. The vertical distances are heats of reaction, first, per pound of gases produced and second, per pound of carbon, the former being a measure of temperature rise, and the latter of efficiency of reaction. These two heats are derived from Eq. (658) in the two Eqs. (661) and (662). *S* is the weight of steam per pound of air reacting.

Chart 34. Here one set of the Mallard and Le Chatelier values for the mean specific heat of various gases given in Eq. (674) has been used to calculate the temperature rise above 32° for various quantities of heat. For any heat increment per pound of gases there is a corresponding temperature increment that can be read off directly. Thus, for CO_2, consider 1 lb. to receive 1000 B.T.U.; starting at 32° F., the temperature rise would be 3290° F. − 32° F. = 3258°,

whereas from 1000° F. as a starting point this same 1000 B.T.U. would yield a temperature of 3690° F. or a rise of 2690°.

Chart 36. The values of the factor of evaporation and equivalent pounds of water per hour per boiler horse-power may be found directly from the curves, which also give the heat per pound for dry saturated, wet or superheated steam above any feed-water temperature. The construction of this chart is given on the diagram.

Charts 38 and 39. These represent a number of boiler tests with some one item of importance, selected to show the effect of various conditions of service and fuels in the same and different boilers, all of which are self explanatory.

Chart 40. Calculation and use of diagram, giving constant volume lines for steam. To illustrate the method, the location of the line of constant volume of 2 cu. ft. will be traced. Let the first temperature be taken at 800° F. absolute for the first point A, corresponding to 340° F. From the steam tables dry saturated steam at 340° F. has a specific volume of 3.786 cu. ft., so that the quality when the volume is 2 cu. ft. is $\frac{2}{3.786}=52.8$ per cent. The entropy of the water at 340° F., from the steam tables, is 0.4903, therefore the entropy increase in making this steam from 32° F. and at 340° F. = entropy of the steam + entropy of water content − entropy at 32° $=\phi_a-\phi_{32}=(.528\times 1.0984+.4903)-0=1.0703$. Another point B is located by assuming a temperature $t_b=440°$ F. or $T_b=900$, for which $\phi_b-\phi_{32}=1.5602$ by the same method.

To illustrate the use of the diagram in solving problems, suppose 1 lb. of wet atmospheric pressure steam, occupying 10 cu. ft. be enclosed in tank and heated to raise the pressure to 30 lbs. per square inch absolute, find the final temperature, entropy and dryness. From 14.7 lbs. per square inch on the pressure scale project to point P on the constant volume line of 10 cu. ft. and follow this line to the point C for 30 lbs. per square inch absolute pressure. Projecting from C to D the absolute temperature is found to be 710° or $t=250°$ F., and projecting from C to E the entropy $\phi_c-\phi_{32}=1.332$. The final quality $=\frac{\overline{CM}}{\overline{OM}}=72.4$ per cent.

Again, if heat be added to raise the temperature to 842° absolute the entropy is found by following the 10 cu. ft. line to the point K opposite the temperature, and projecting down from K to Q the entropy is found $\phi_k-\phi_{32}=1.724$. The quality may be read off directly from Chart 44 which carries lines of constant quality that might be superimposed on this constant-volume chart.

Charts 41, 42 and 43. These have been drawn to facilitate calculations of P, V, T relations for expansions and compression having various values of s; Charts 41 and 42 have been plotted to a vertical scale of $\left(\frac{P_1}{P_2}\right)$, with a double horizontal scale for the corresponding $\left(\frac{V_2}{V_1}\right)$ and $\left(\frac{T_1}{T_2}\right)$. Each curve is for a different value of s, as marked on it. These are also given on logarithmic

cross-section paper in Chart 43 as arranged by Gunn, where all lines become straight, to which an entropy scale is added.

Chart 44. Calculation and use of temperature entropy diagram, lines of constant pressure and quality. Let it be assumed that the line of quality 80 per cent is to be located, starting with the pressure of 200 lbs. per square inch absolute, point *A*. From the steam tables $t = 381.9°$ F. or $T_a = 841.9$, the entropy of the liquid is .5437, of evaporation complete, 1.0019, so that $\phi_a - \phi_{32} = .8 \times 1.0019 + .5437 = 1.3452$. To locate a point *B* in the superheat region at the same pressure and for 100° of superheat, the steam tables are found to give directly $\phi_b - \phi_{32} = 1.6120$.

The following problem will serve as an example of the use of the diagram. Steam at a pressure of 160 lbs. per square inch absolute, dry and saturated expands adiabatically to atmospheric pressure and to some unknown quality to be found. From the point *C* representing the initial condition project vertically down to the pressure line 14.7, at point *D*. By interpolation the quality is found to be 86.5 per cent, as point *D* lies between the two lines of 80 per cent and 90 per cent quality.

Another example will illustrate the passage into the superheat region. Atmospheric exhaust steam at 20 lbs. per square inch absolute, is superheated 120° by a reheater and then expands adiabatically in an exhaust steam turbine to an absolute pressure of half a pound per square inch absolute, to find the final quality. The initial condition is represented by point *E*, from which projecting downward to the low-pressure line at *H*, lying between 80 per cent and 90 per cent, the quality is found by interpolation to be 88.4 per cent and the temperature by projecting to *K*, is $T = 540°$. The corresponding volumes may be read off from Chart 40.

Chart 45. The Mollier Diagram. On this diagram the total heats above 32° are ordinates, and entropy from 32° are abscissa, plotted in a series of curves. On this chart the vertical distance from any pressure, temperature or quality, to any other, is the work done in heat units, by the whole cycle including an adiabatic expansion; this can be marked off on a strip of paper and referred to the scale of heat to permit the work to be read directly, or the ordinate of the low can be subtracted from that of the high point. As this is so convenient for turbine work a scale of corresponding steam jet velocities has been plotted beside that for total heats. A large scale chart of this sort is very necessary when many calculations of this nature are to be made and such may be plotted from the steam tables.

Chart 46. To illustrate the use of the diagram, the following problem will be graphically solved. Find the Rankine cycle efficiency, heat and steam consumption for an initial pressure of 150 lbs. per square inch gage and dry saturated steam with a back pressure of 10 lbs. per square inch absolute. Starting at the initial pressure point *B*, project up to the 10-lb. back pressure curve point *C*, and then across to the efficiency scale point *D*, reading there a thermal efficiency of 19.3 per cent and a heat consumption of 13,200 B.T.U. per hour per I.H.P. Continuing across horizontally to the back pressure curve of 10

lbs. in the left-hand angle to point E and thence downward to the water-rate scale point F, the value 12.6 lbs. steam per hour per I.H.P. is read off directly.

Chart 47. To illustrate the use of this chart, find the thermal efficiency, heat and steam consumption, for the Rankine cycle, when steam is 90 per cent initially dry at 200 lbs. per square inch gage pressure, and the back pressure 15 lbs. per square inch absolute. From the scale of quality at 90 per cent, point E, project up to point F on 15-lb. curve, and then horizontally to point G at 18.98 per cent thermal efficiency and 13,400 B.T.U. per hour per I.H.P. heat consumption. Continue across to H and down to K, reading the water rate value 14.4 lbs. of steam per hour per I.H.P. on the bottom scale.

Chart 48. To illustrate the use of this diagram, find the jet velocity, work per pound of steam, and mean effective pressure for the Rankine cycle for steam at 75 lbs. initial pressure gage, dry and saturated expanding to 10 lbs. absolute. Project up from point B to point C and across to point F where there is read, work done = 115,000 ft.-lbs. per pound of steam. Continuing across to D and down to E, (m.e.p.) = 23.5 lbs. per square inch, or continuing CD across to G the jet velocity is 2790 ft. per second.

Chart 49. To illustrate the use of this diagram, find work, jet velocity, and mean effective pressure, for the Rankine cycle when initial pressure is 200 lbs. per square inch gage, 50° superheat and back pressure 1 lb. per square inch absolute. Projecting up from point E to F and across to G, read, work = 272,000 ft.-lbs., velocity = 4190 ft. per second, and stopping on the 1-lb. curve at point H the mean pressure 7.4 lbs. per square inch is read directly below at K.

Chart 50. Carnot steam cycle. To illustrate the use of the diagram, solve the problem: For the Carnot cycle with dry saturated steam between 150 lbs. per square inch gage and 10 lbs. absolute find the thermal efficiency, heat, and steam consumption. From point B pass up to C and across to D, reading efficiency = 21.1 per cent, and heat consumption 12,060 B.T.U. per hour per I.H.P. Passing horizontally to E and down to F' the water rate of 13.9 lbs. per hour per I.H.P. may be read off directly.

Charts 51, 52 and 53. Carnot steam cycle. The use of these diagrams requires no special explanation since they follow in general the methods given for the Rankine cycle charts.

Chart 54. Non-compression gas cycle. To illustrate the use of the diagram find for a Lenoir cycle receiving 800 B.T.U. per pound of working gases the thermal efficiency, heat consumption, and cubic feet of 300 B.T.U. per cubic foot fuel gas per hour per I.H.P. From the 800 point E pass vertically to point F on the Lenoir curve and thence horizontally to G on the efficiency scale, reading 35.2 per cent and heat consumption, 7250 B.T.U. per hour per I.H.P. Passing across to the 300 B.T.U. calorific power curve at H and down to K, the gas consumption is found to be 24 cu. ft. per hour per I.H.P.

Chart 55. Work of the non-compression gas cycle. The following problem illustrates the use of this diagram: Find the work per pound of working gases and the mean effective pressure for an Otto and Langen cycle receiving

500 B.T.U. per pound of gases. Starting at the 500 B.T.U. point G, pass up to the cycle curve at H and then across to the point K on the work scale, reading 260,000 ft.-lbs. Passing horizontally across to the point L and thence downward to point M the mean effective pressure is found to be 1.18 lbs. per square inch.

Chart 56. Stirling gas cycle. To illustrate the use of this chart, find the efficiency, cyclic and fuel heat consumption for a Stirling cycle, for 300 B.T.U. supplied from fire per pound of working gases, 30 atm. compression, and a furnace efficiency of 40 per cent. Starting at point E at the value 300 on the upper scale, pass vertically up to point F on the efficiency curve referred to fire heat, and horizontally to G, reading thermal efficiency of 62.8 per cent, and cyclic heat supplied 4050 B.T.U. per hour per I.H.P. Continuing across to point H on the 40 per cent furnace efficiency curve and down to fire heat scale at K, the fire heat supplied is found to be 10,200 B.T.U. per hour per I.H.P.

Charts 57 and 59. A similar procedure applies to the curves for the Ericsson cycle, which need no detailed explanation.

Charts 60 and 61. Adiabatic compression cycles. Illustrating the use of the curves the solution of the following problem is traced graphically on Chart 60. Required the thermal efficiency, cyclic heat, and fuel consumption for the Diesel cycle, supplied with an oil yielding 1500 B.T.U. per cubic foot in its vapor, the cycle receiving 600 B.T.U. per pound of working gases after 10 atm. compression. From the 600 point E on the heat-supplied scale pass up to the 10 atm. compression Diesel curve F, and horizontally across to the efficiency scale G reading 28.6 per cent and 8900 B.T.U. per hour per I.H.P. Continuing across to the fuel calorific power curve of 1500 B.T.U. per cubic foot H, and thence down to K, the fuel consumption is found to be 6 cu.ft.

The second set of efficiency curves, Chart 61, is used in exactly the same way as Chart 60, the only difference between the two being the scales.

Charts 66 and 67. Comparison of rational and emperic formulas for air and steam flow. These have been calculated for air from Eq. (25) using $\gamma = 1.4$; and by the Mollier diagram for steam. To this diagram are added some curves of experimental flow laws stated in Eqs. (951), (952) and (953).

Chart 69. Velocity of air pipes. This diagram was calculated from Eq. (968) and also by the simple equation in which density changes are neglected. These give comparative results as indicated in the chart, reproduced from Kneeland.

Chart 71. Chimney diameter. This diagram corresponds to Eq. (1005) which assumes that the minimum-cost steel stack has a diameter depending solely upon the horse-power of the boilers it serves, and a height proportional to the net draft required.

Charts 72 and 73. Refrigerating effect, ammonia and carbon-dioxide. See the diagrams for construction and use.

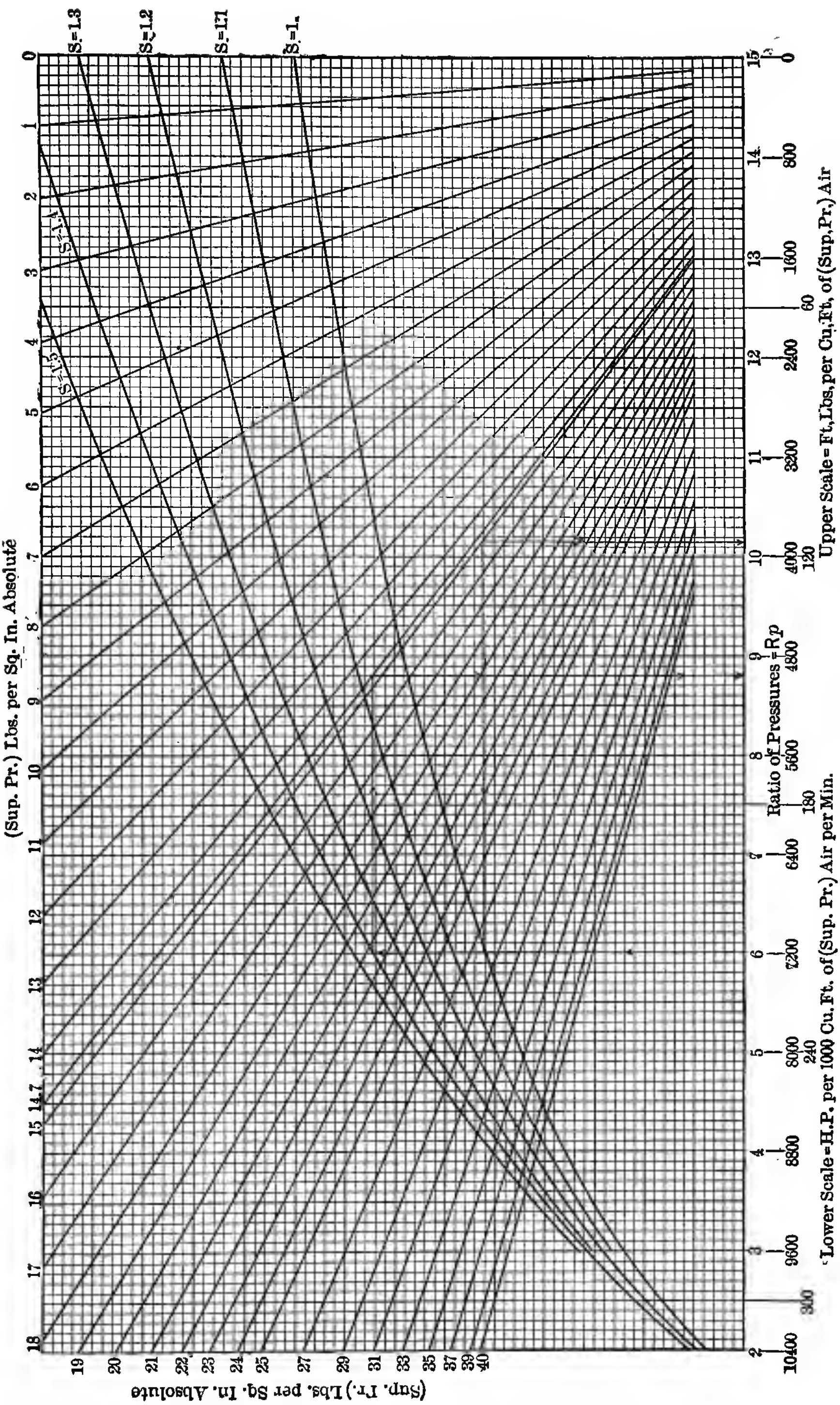


CHART 1.—Work per Cubic Foot and Horse-power per 1000 Cubic Feet per Minute of Supply Pressure Gas for *Single-stage Compressors.*

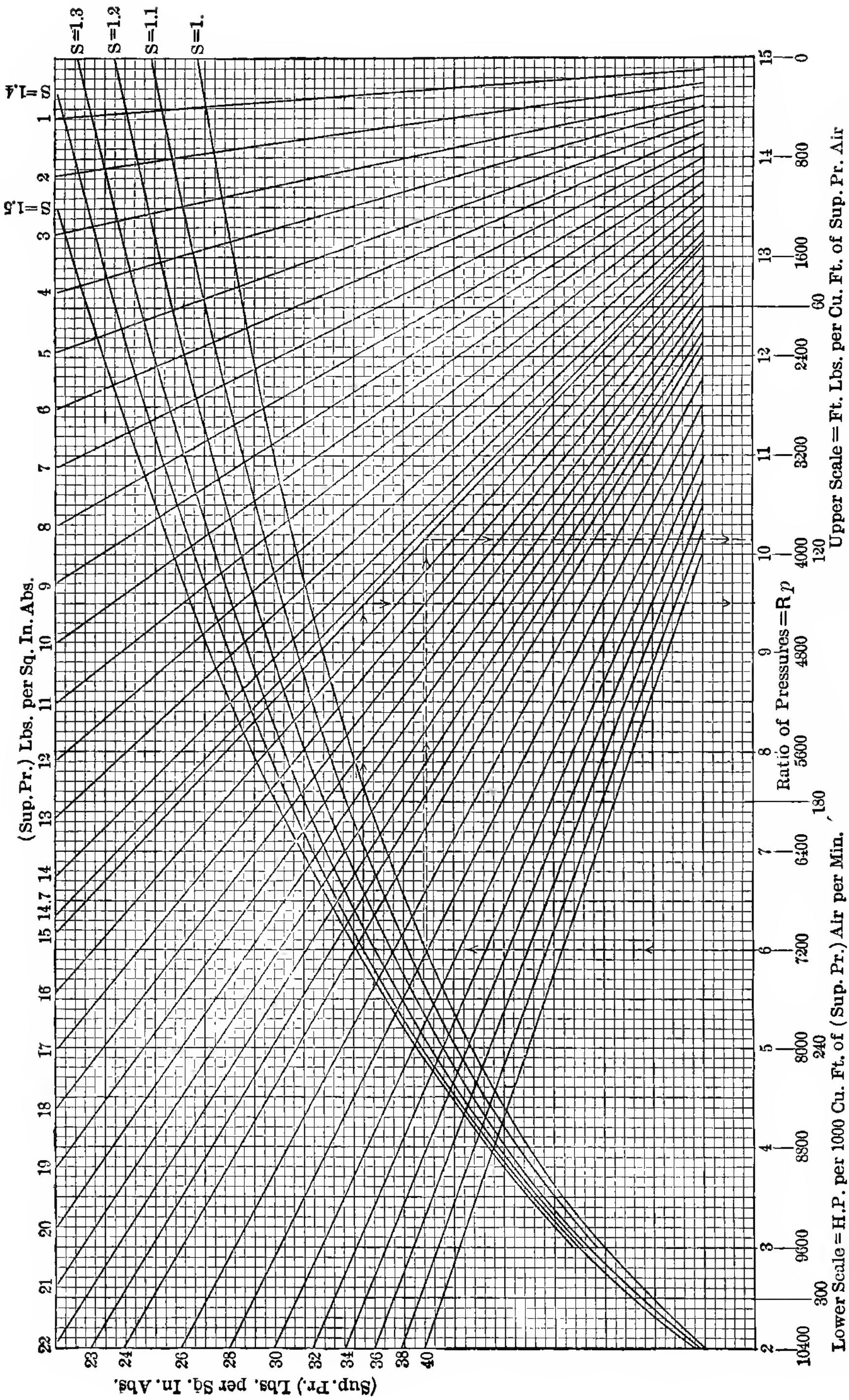


CHART 2.—Work per Cubic Foot and Horse-power per 1000 Cubic Feet per Minute of Supply Pressure Gas for *Two-stage Compressors,* Best Receiver-pressure, Perfect Intercooling.

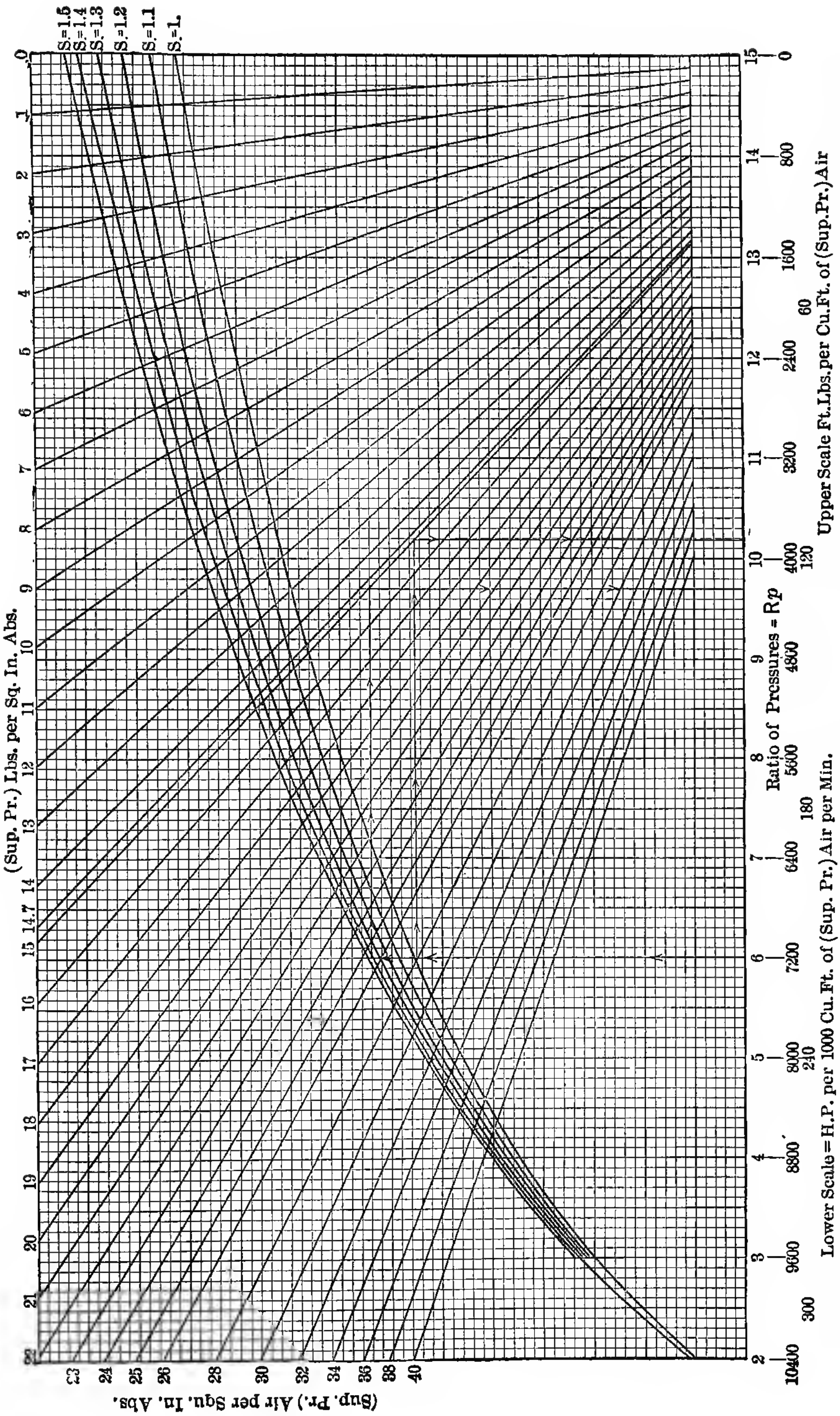


CHART 3.—Work per Cubic Foot and Horse-power per 1000 Cubic Feet per Minute of Supply Pressure Gas for *Three-stage Compressors*, Best Two-receiver-pressures, Perfect Inter-cooling.

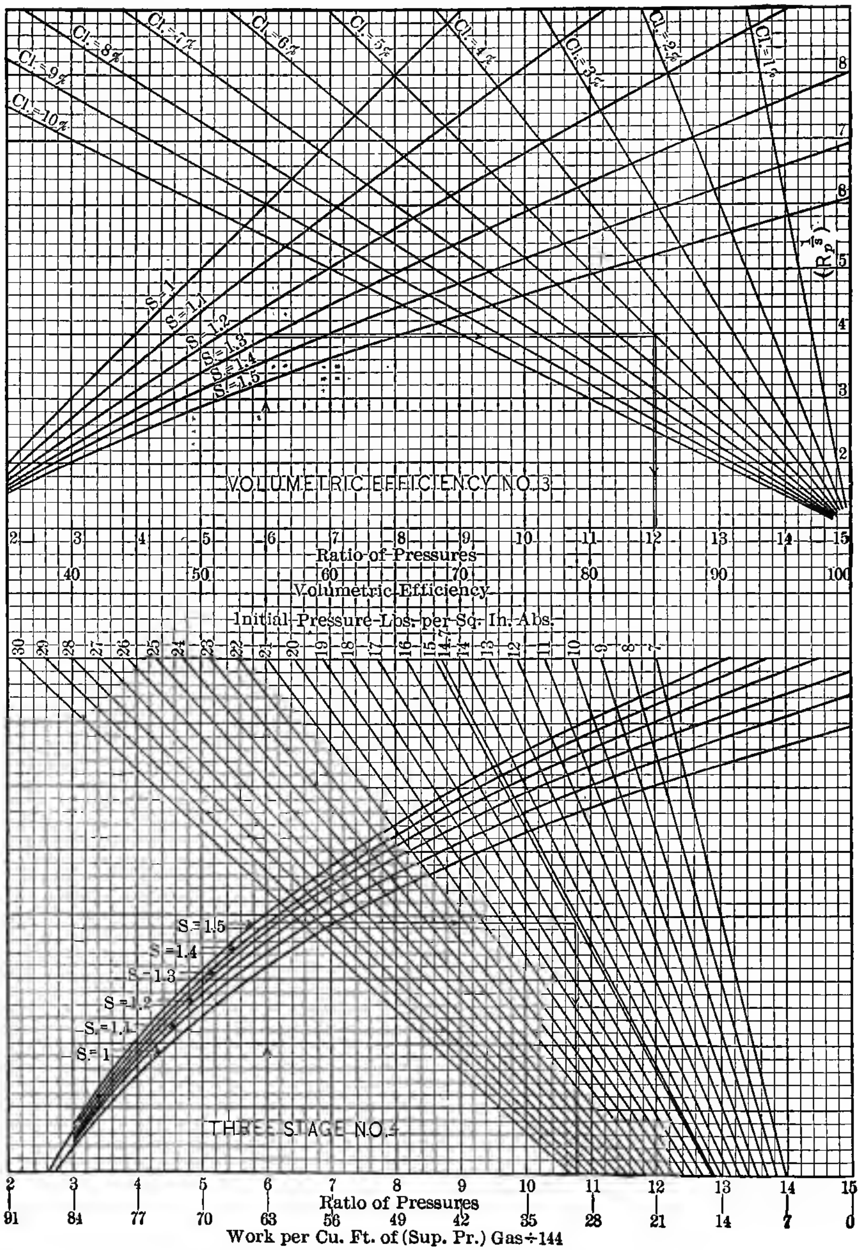


CHART 4.—Mean Effective Pressure of Compressors, One-, Two-, and Three-stages.

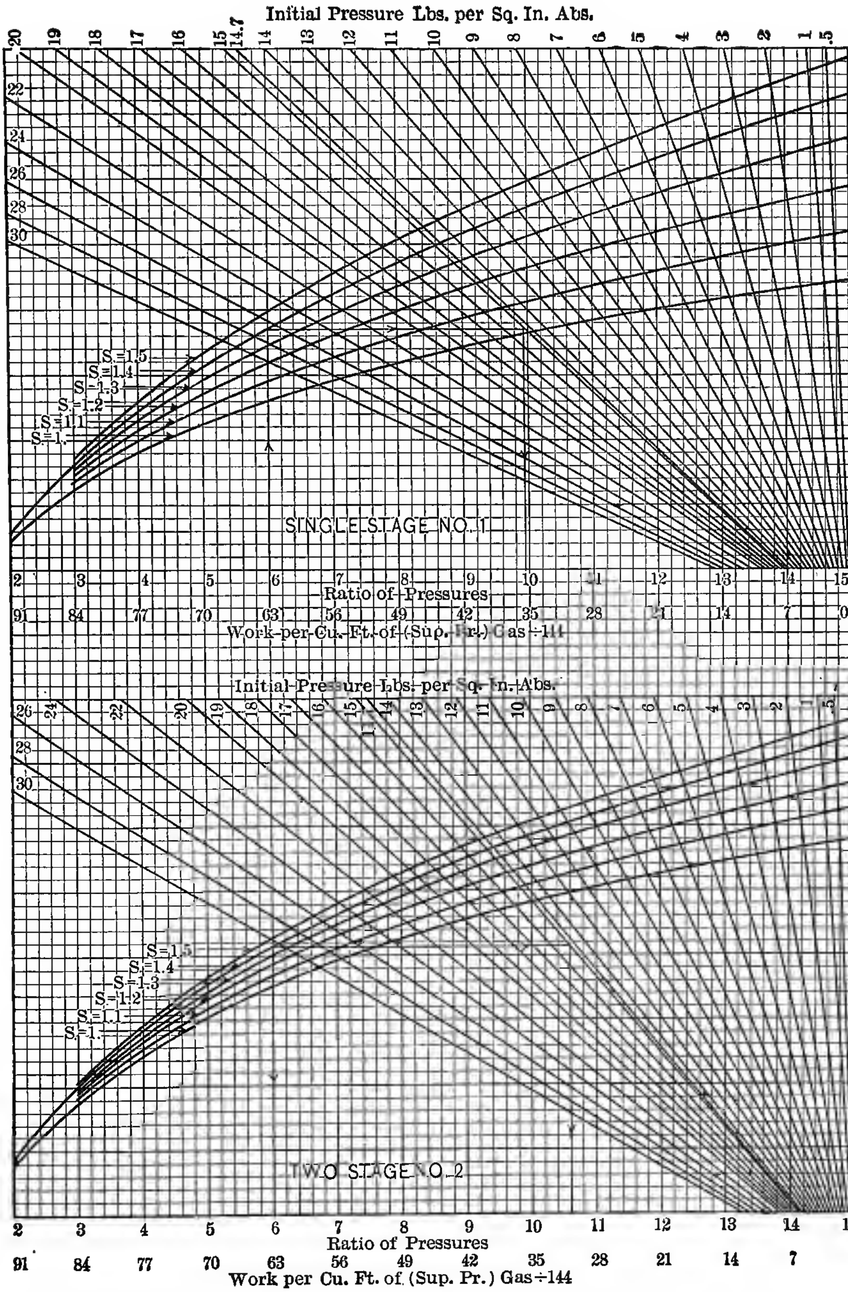
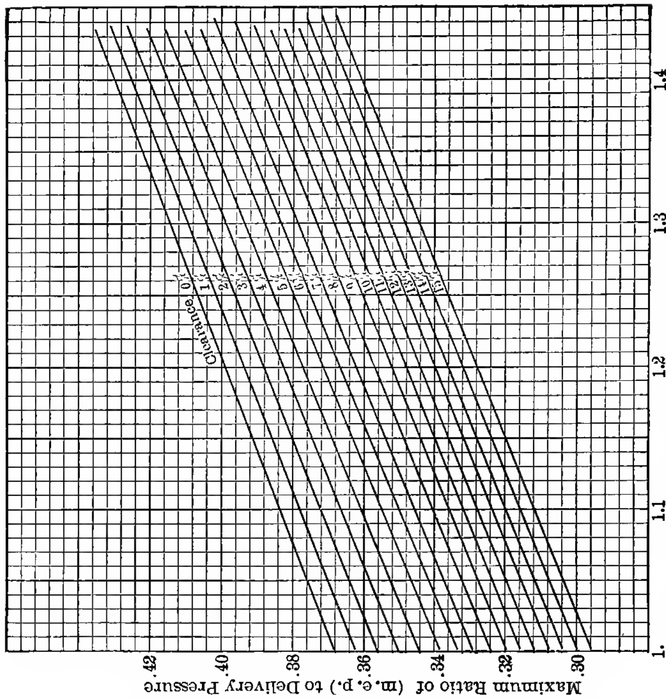


CHART 4.—Mean Effective Pressure of Compressors, One-, Two-, and Three-stages.



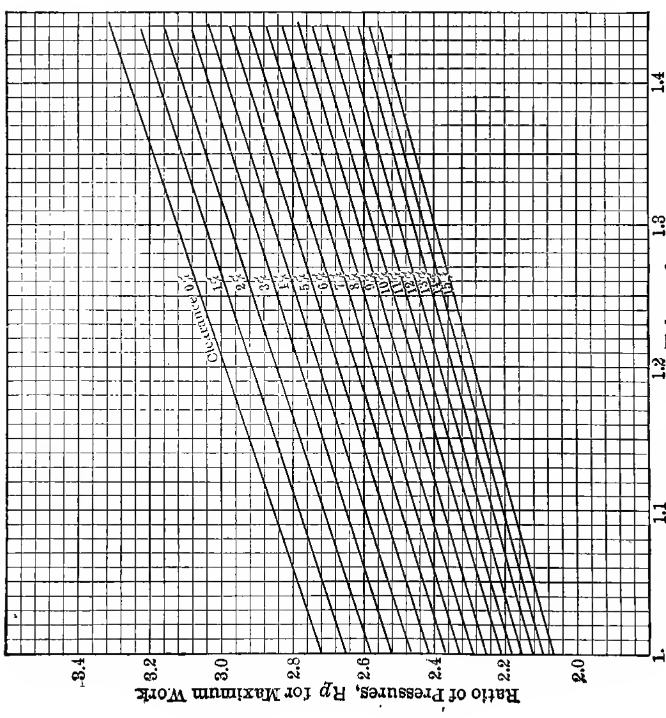


CHART 5.—Value of Supply Pressure that Results in Maximum Work and Corresponding Mean Effective Pressure.

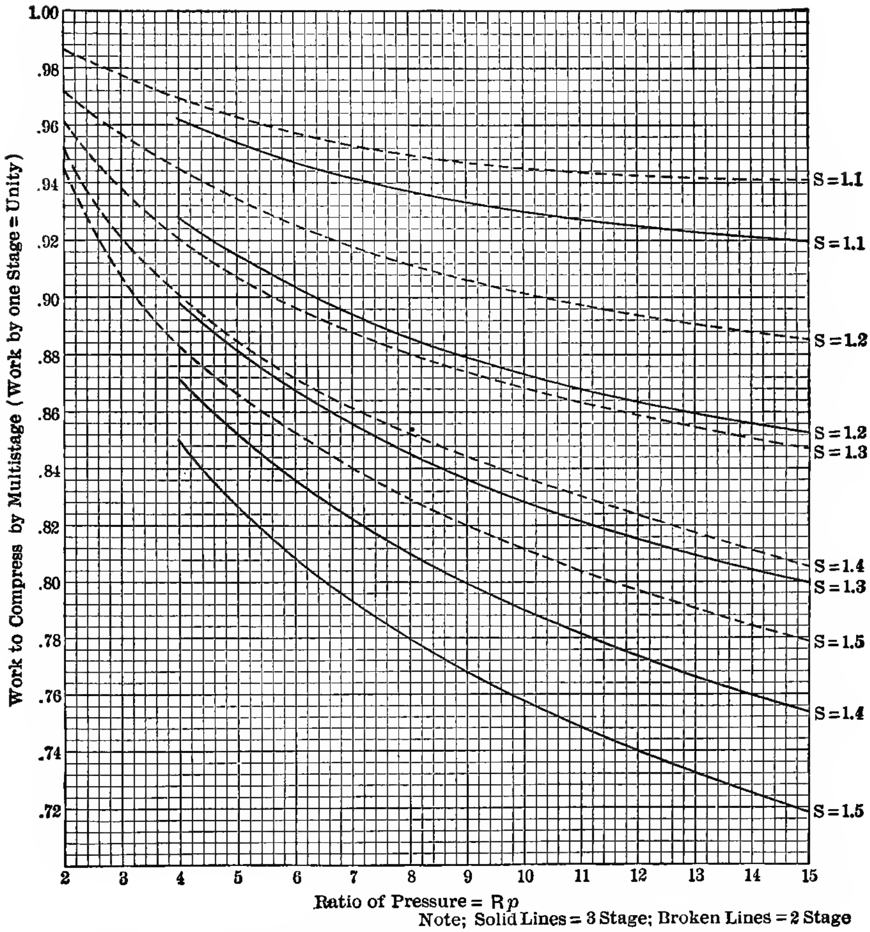


CHART 6.—Relative Work of Two-stage and Three-stage Compressors Compared to Single Stage.

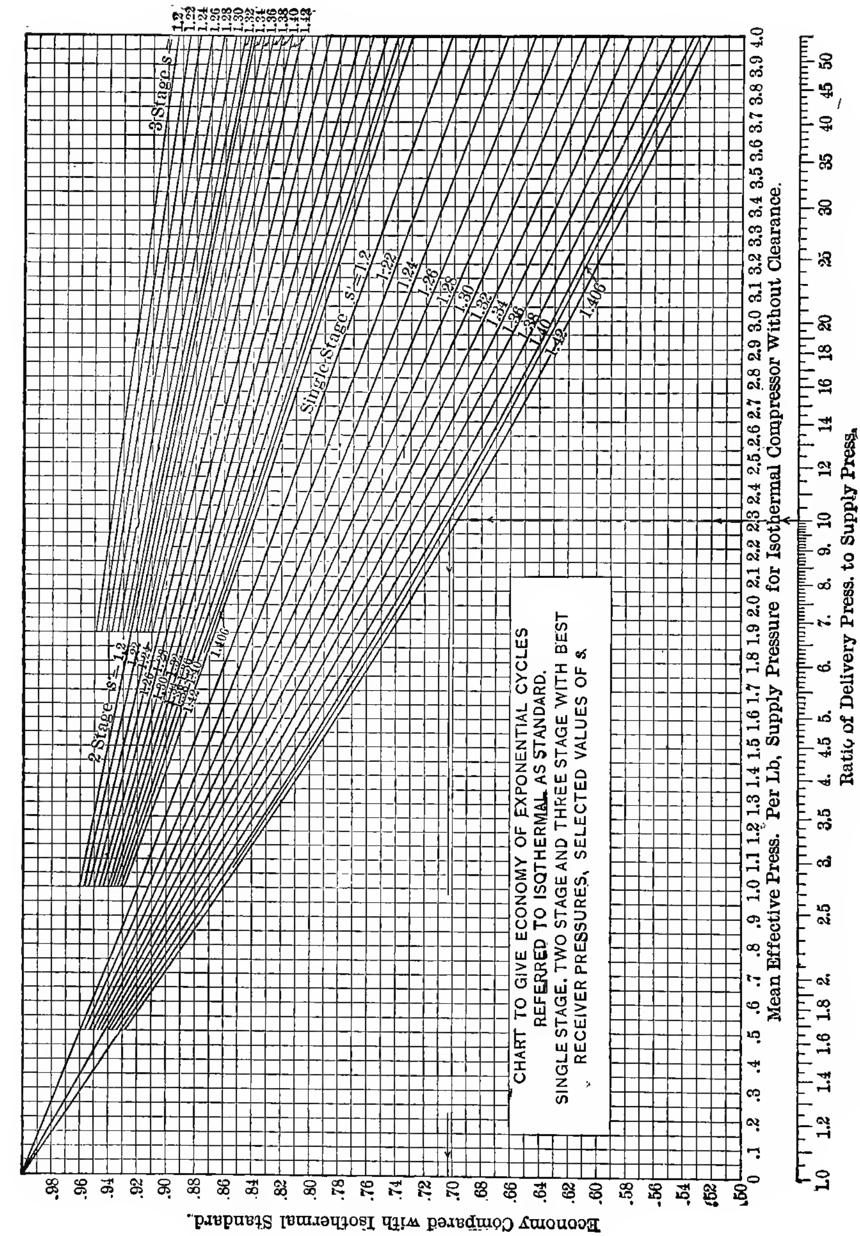


CHART 7.—Diagram to give Economy of Exponential Cycles referred to Isothermal as Standard.

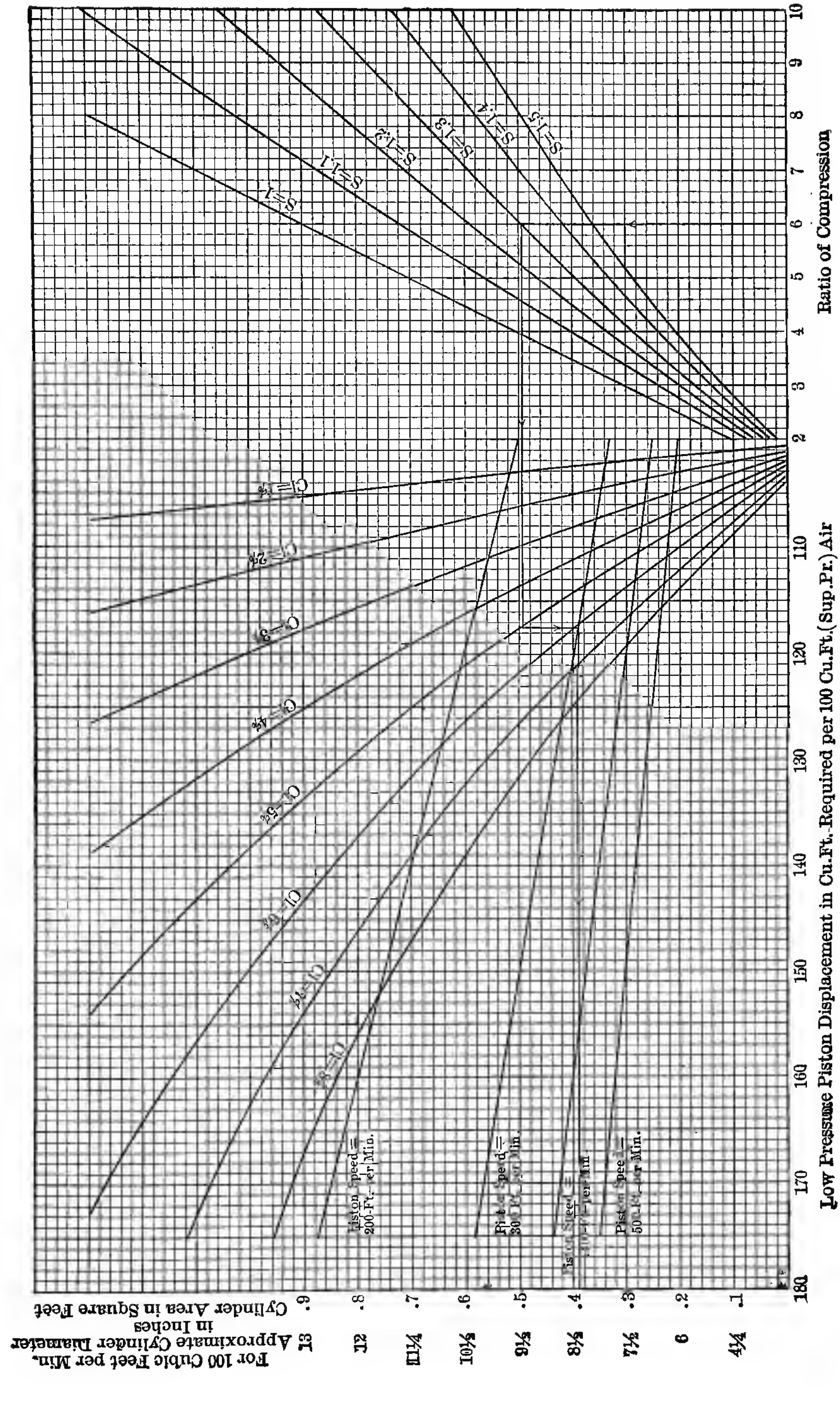


Chart 8.—Compressor Cylinder Displacement for Given Capacity.

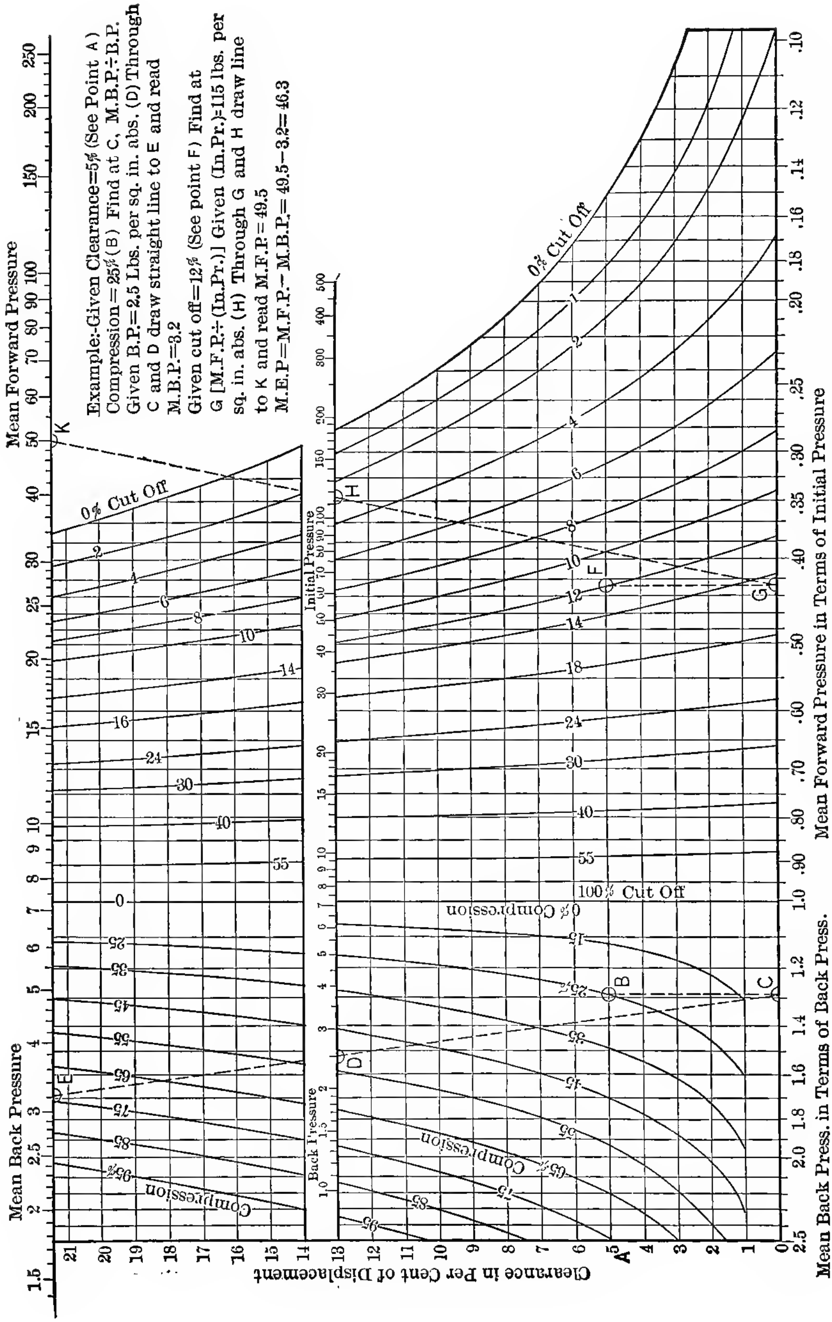


CHART 9.—Graphical Determination of Mean Effective Pressure for Single Cylinder Engines with Clearance, Logarithmic Expansion and Compression.

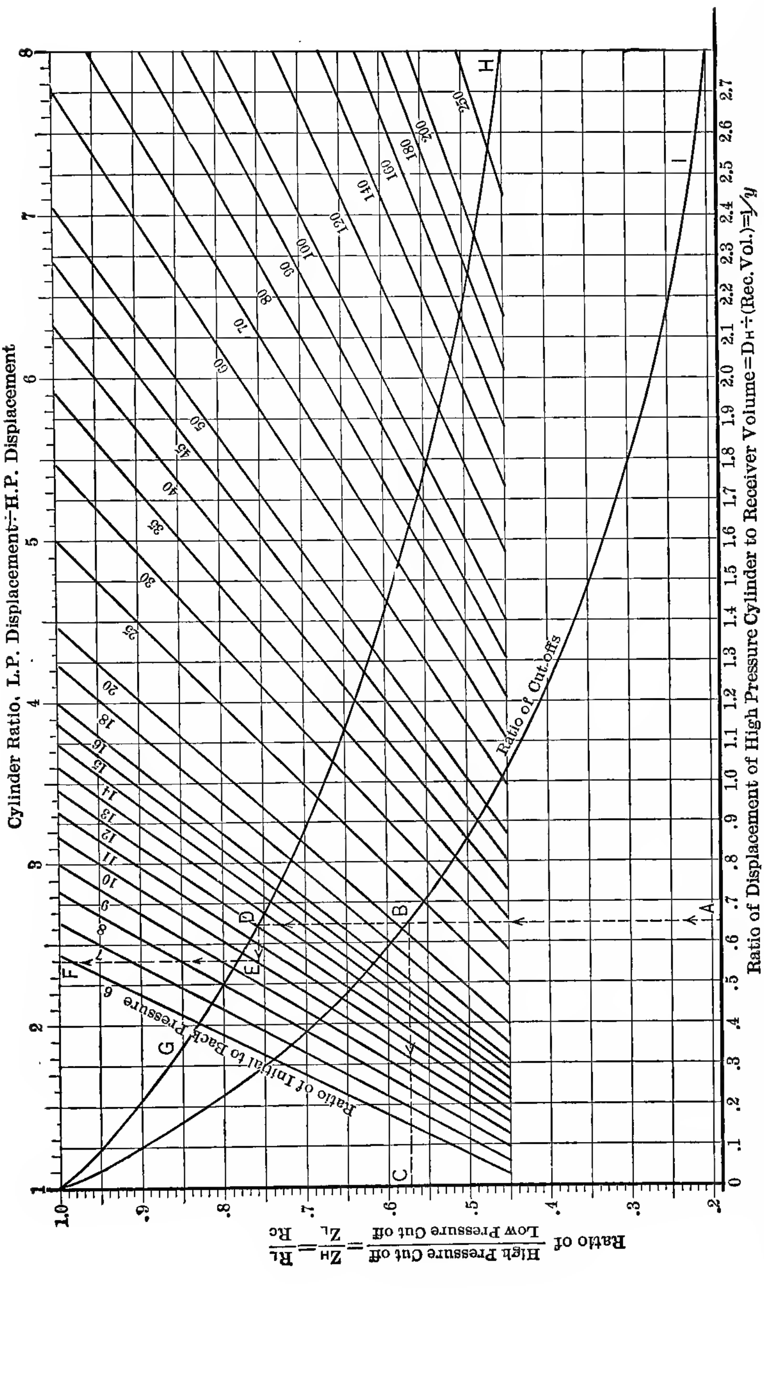


CHART 10.—Relations for Equal Distribution of Work in Compound Engine with Finite Receiver and No Clearance when Expansion is Logarithmic, Complete in both Cylinders and High-Pressure Exhaust and Low-pressure Admission are Not Coincident. Cycle No. VII.

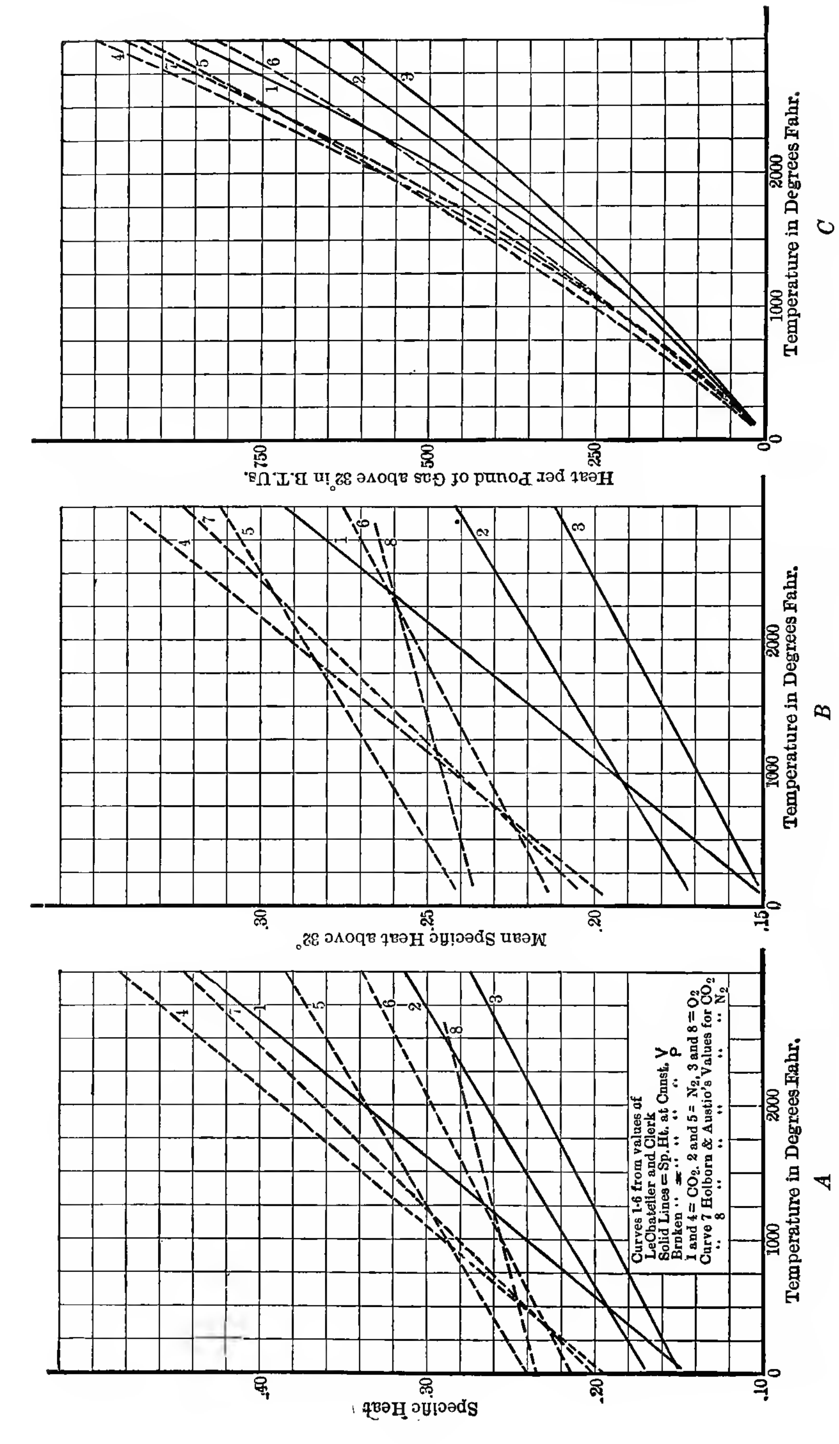


CHART 11.—Specific Heat of Gases at, Mean Specific Heat from 32° F. to, and Total Heat per Pound from 32° F. to, Various Temperatures.

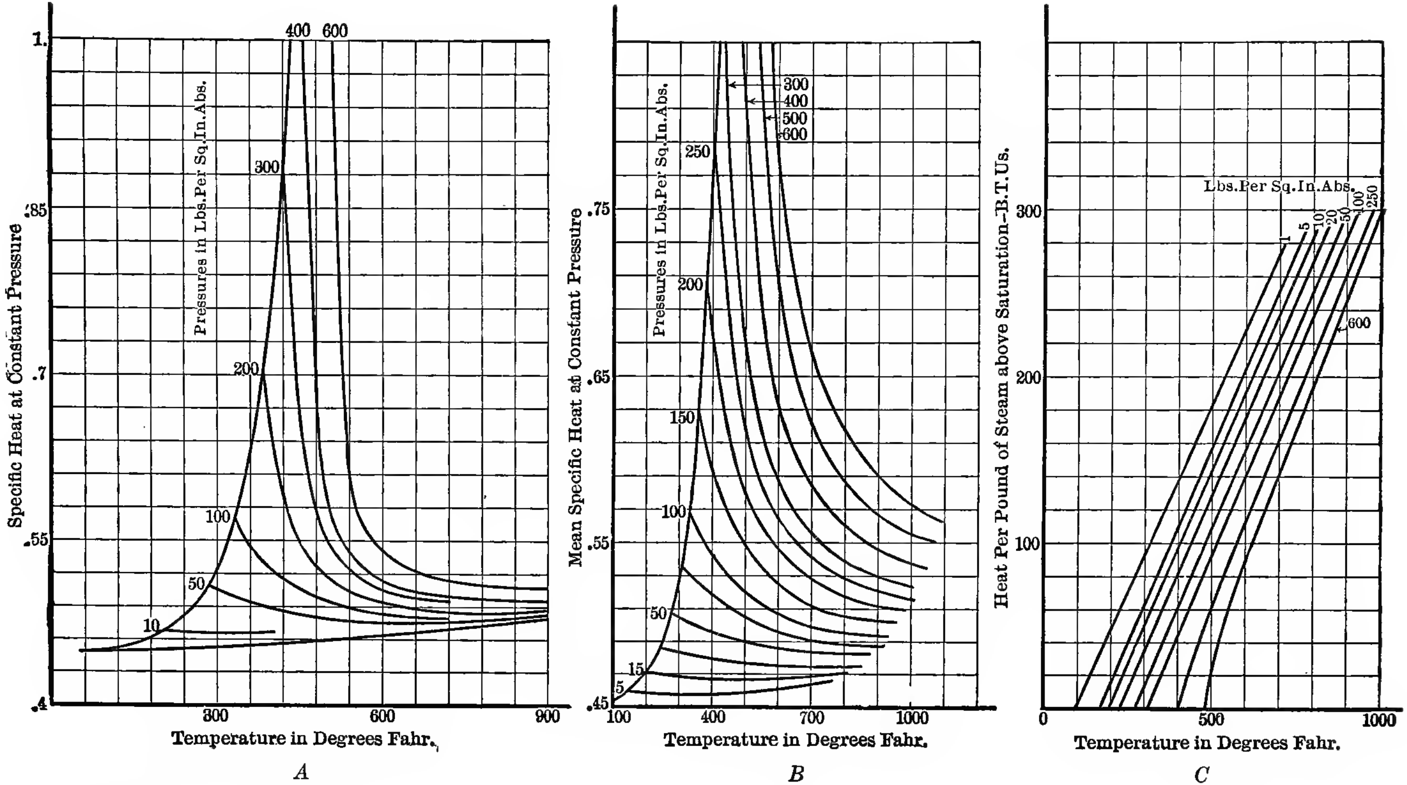
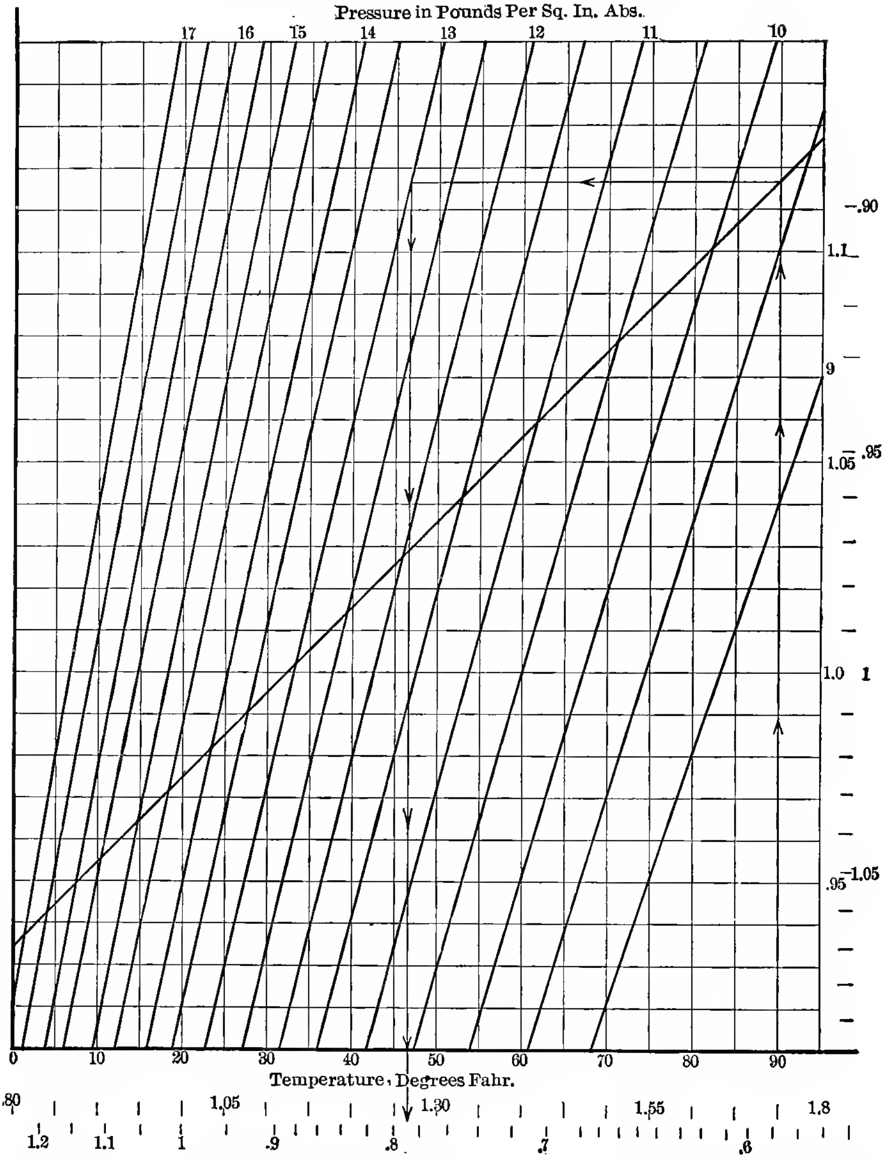


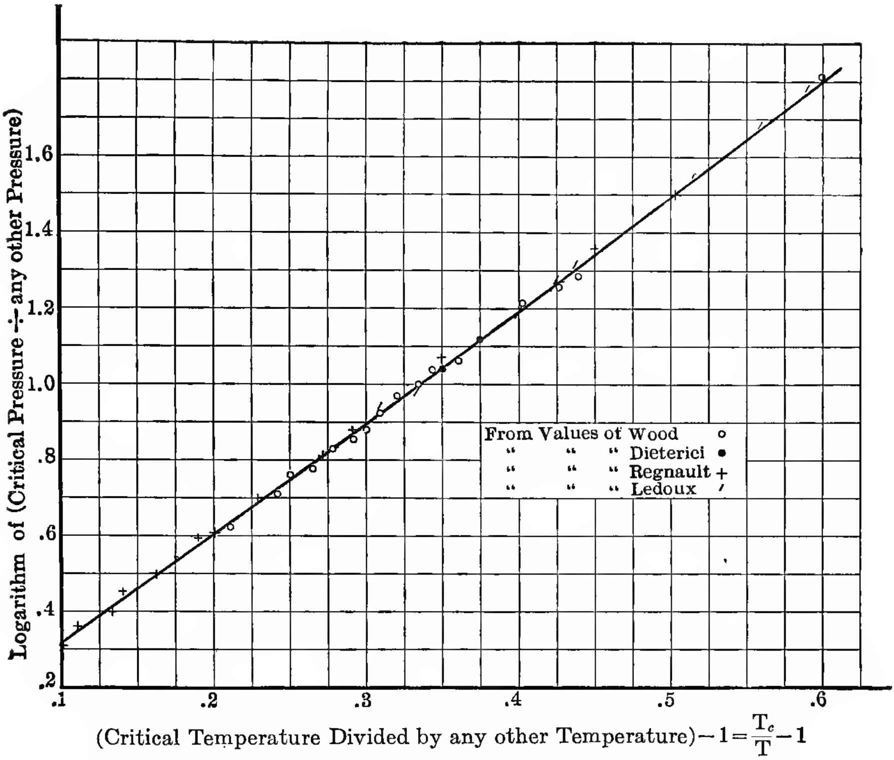
CHART 12.—Specific Heat of Superheated Steam at, Mean Specific Heat from Saturation Temperature to, and Heat of Superheat per pound from Saturation Temperature to, Various Temperatures.



Upper Scale = Ratio $\frac{\text{Density at } 32°\&29.92''}{\text{Density at any T\&P}}$ Lower Scale = Ratio $\frac{\text{Volume at } 32°\&29.92''}{\text{Volume at any T\&P}}$

Outer Scale = Ratio $\frac{\text{Volume at } 32° \text{ F.}}{\text{Volume at any T}}$ Inner Scale = Ratio $\frac{\text{Density at } 32° \text{ F.}}{\text{Density at any T}}$

CHART 13.—Equivalent Gas Densities At Different Pressures and Temperatures.



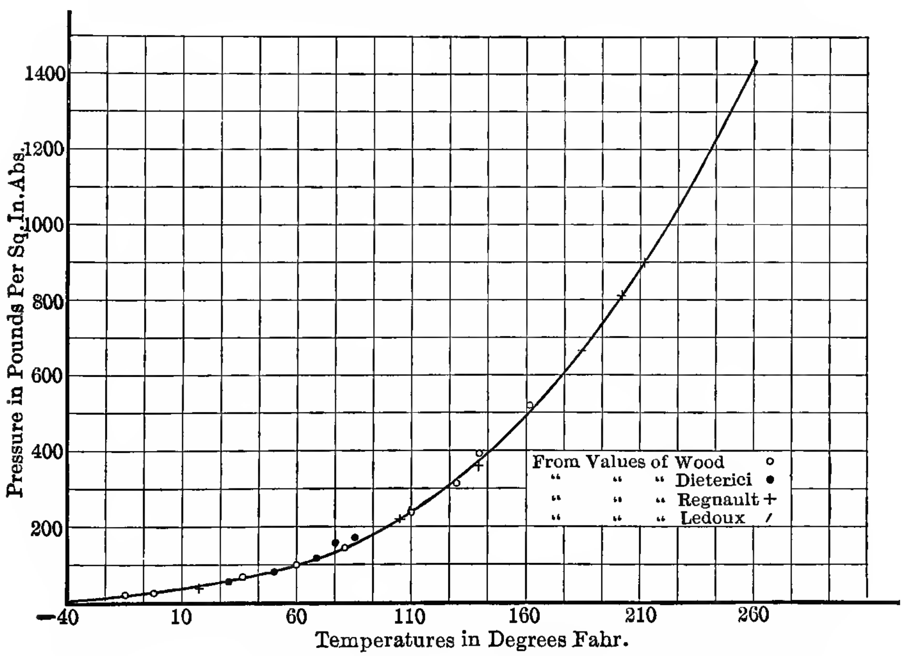
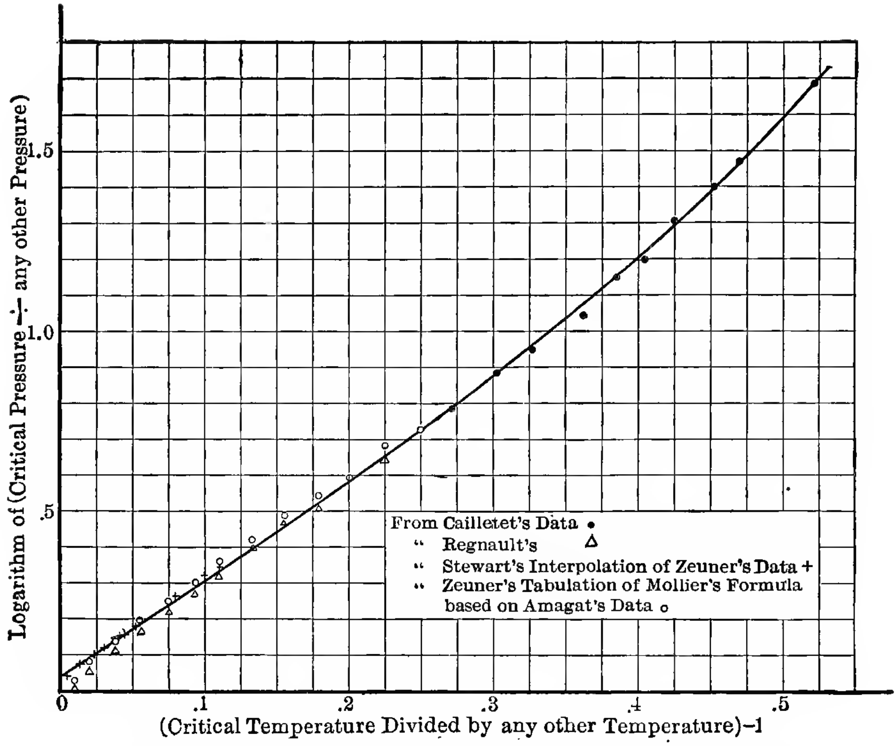


CHART 14.—Ammonia Pressure-temperature Relations, for Saturated Vapor.



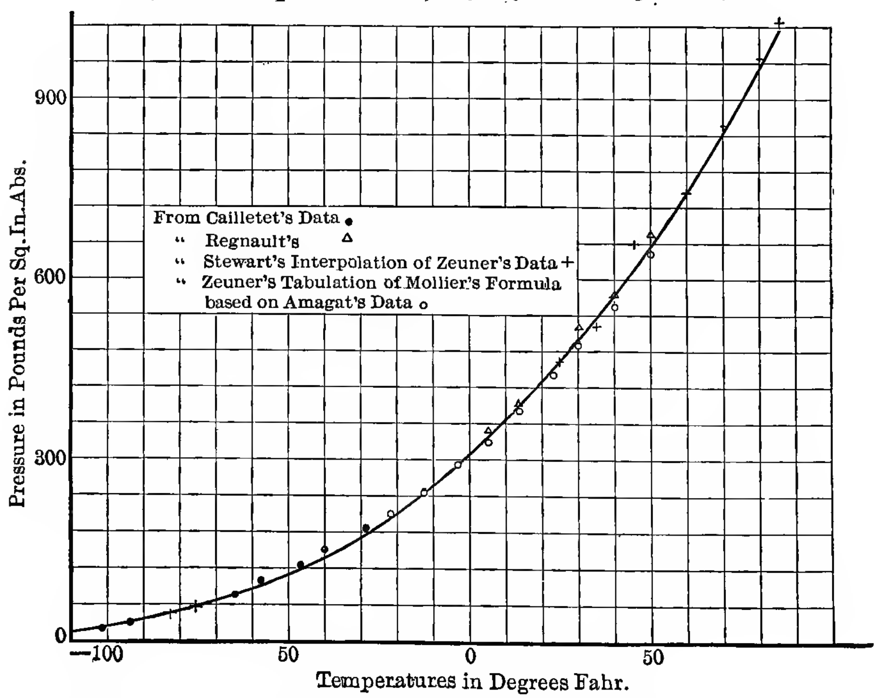


Chart 15.—Carbon Dioxide Pressure-temperature Relations for Saturated Vapor.

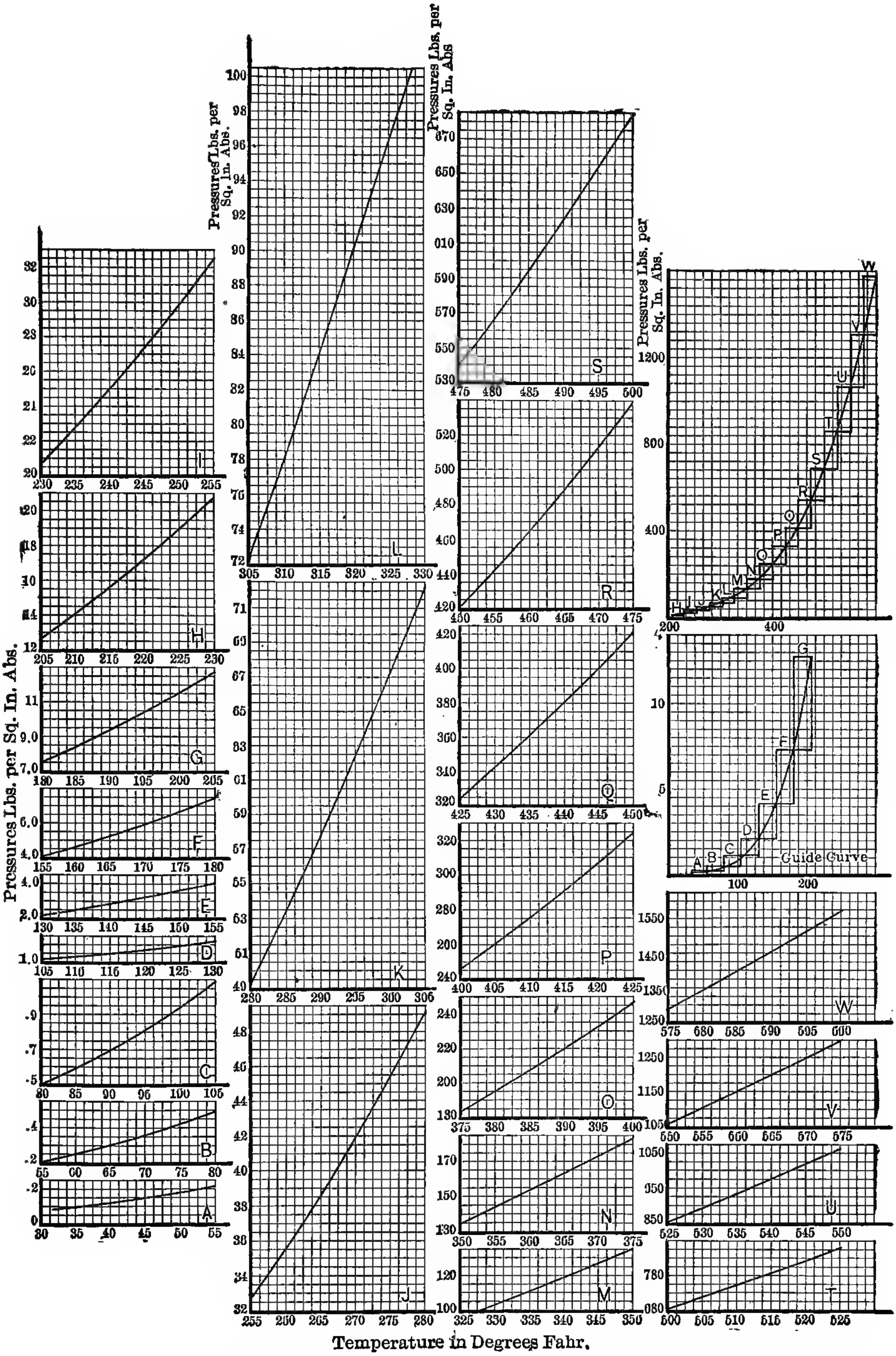


CHART 16.—Steam, Pressure-temperature (Table XL).

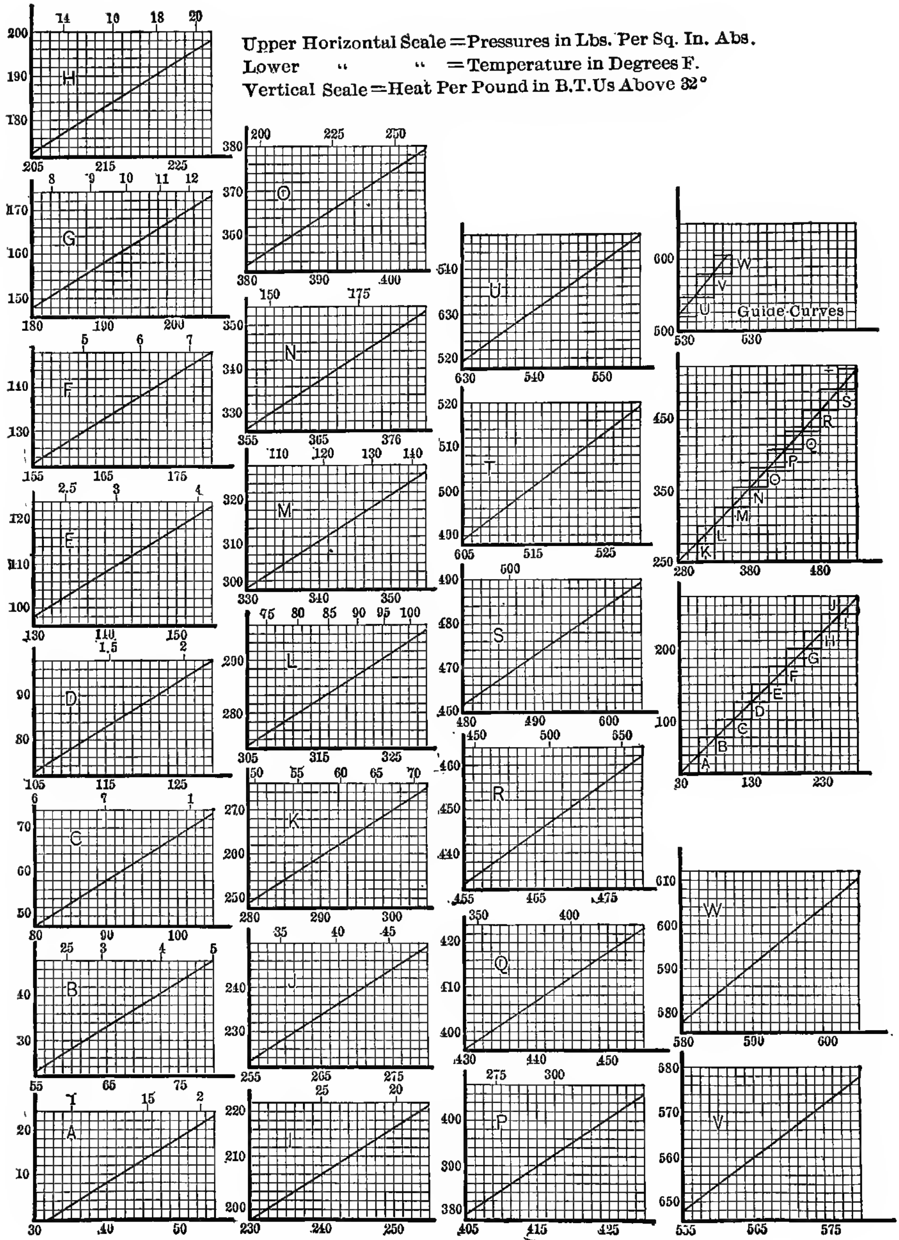


CHART 17.—Steam, Heat of the Liquid (Table XL).

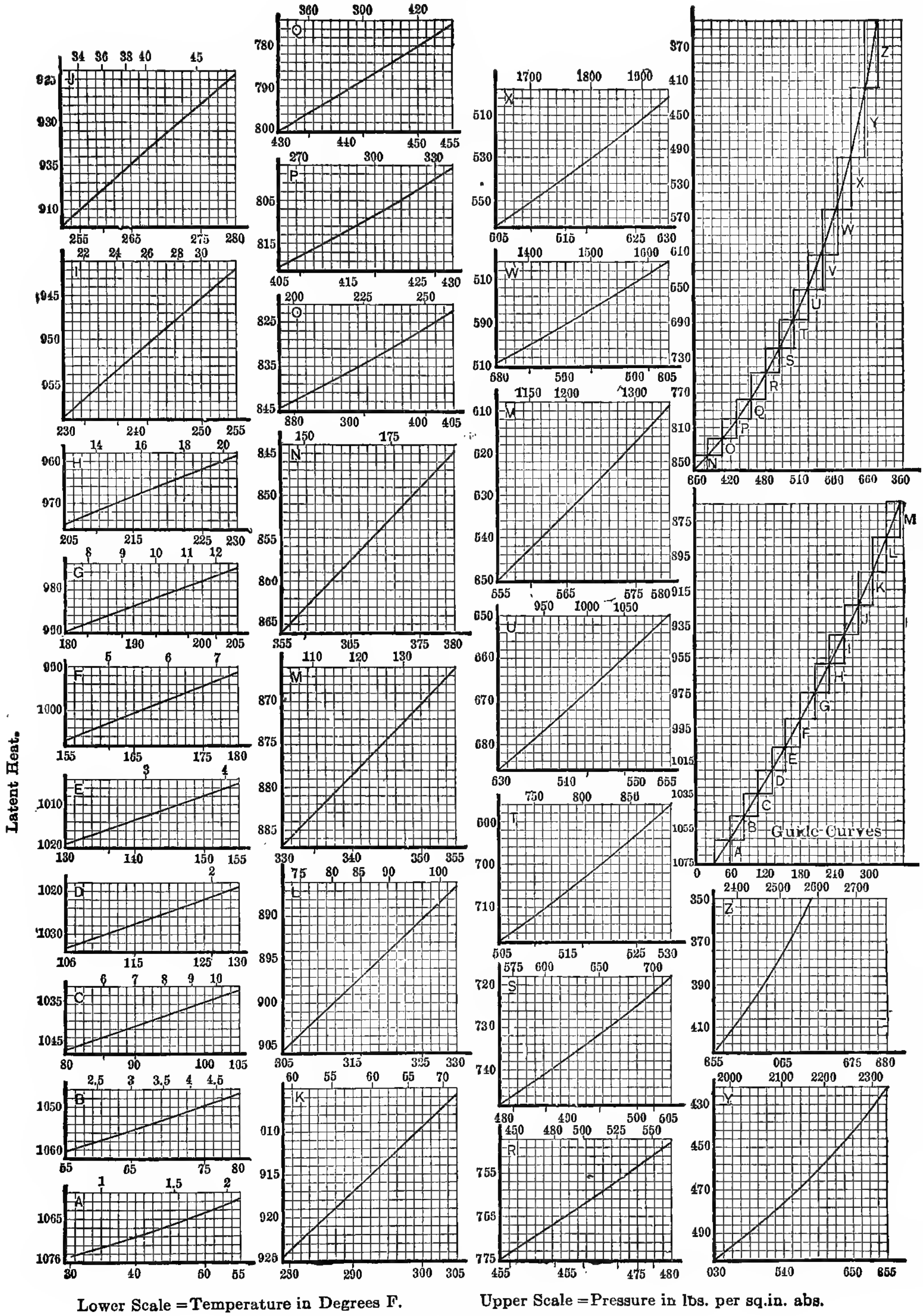


CHART 18.—Steam, Latent Heat (Table XL).

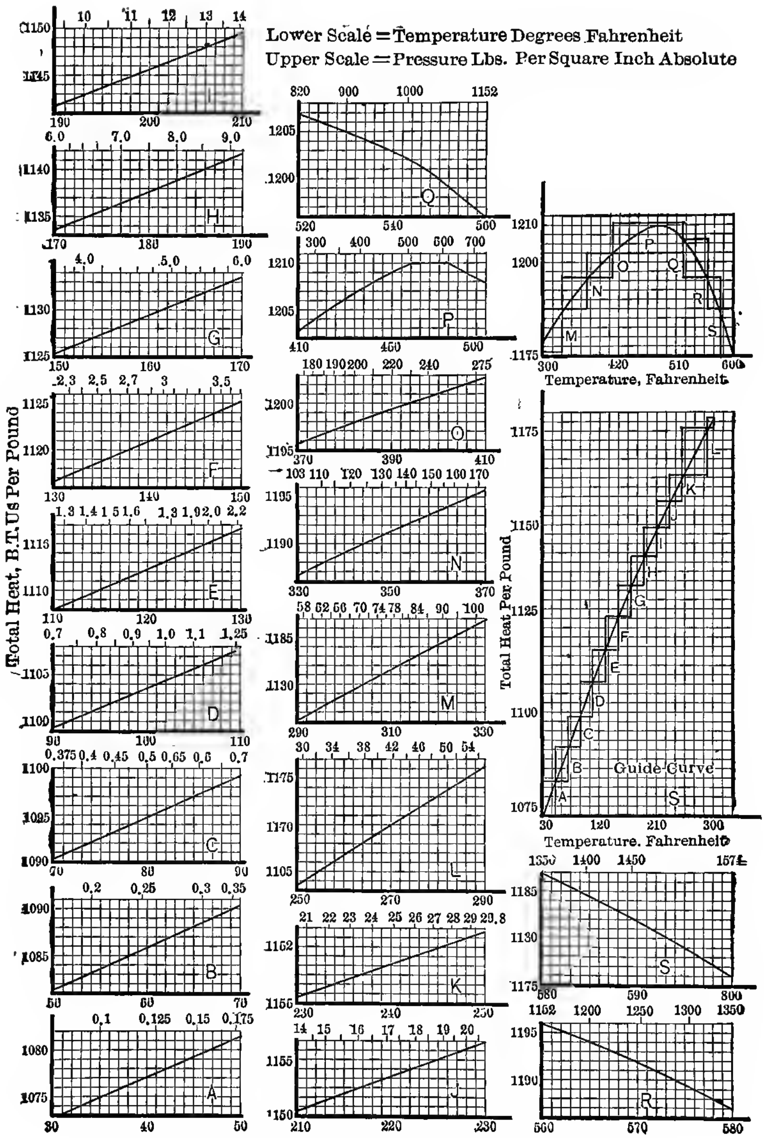


CHART 19.—Steam, Total Heat (Table XL).

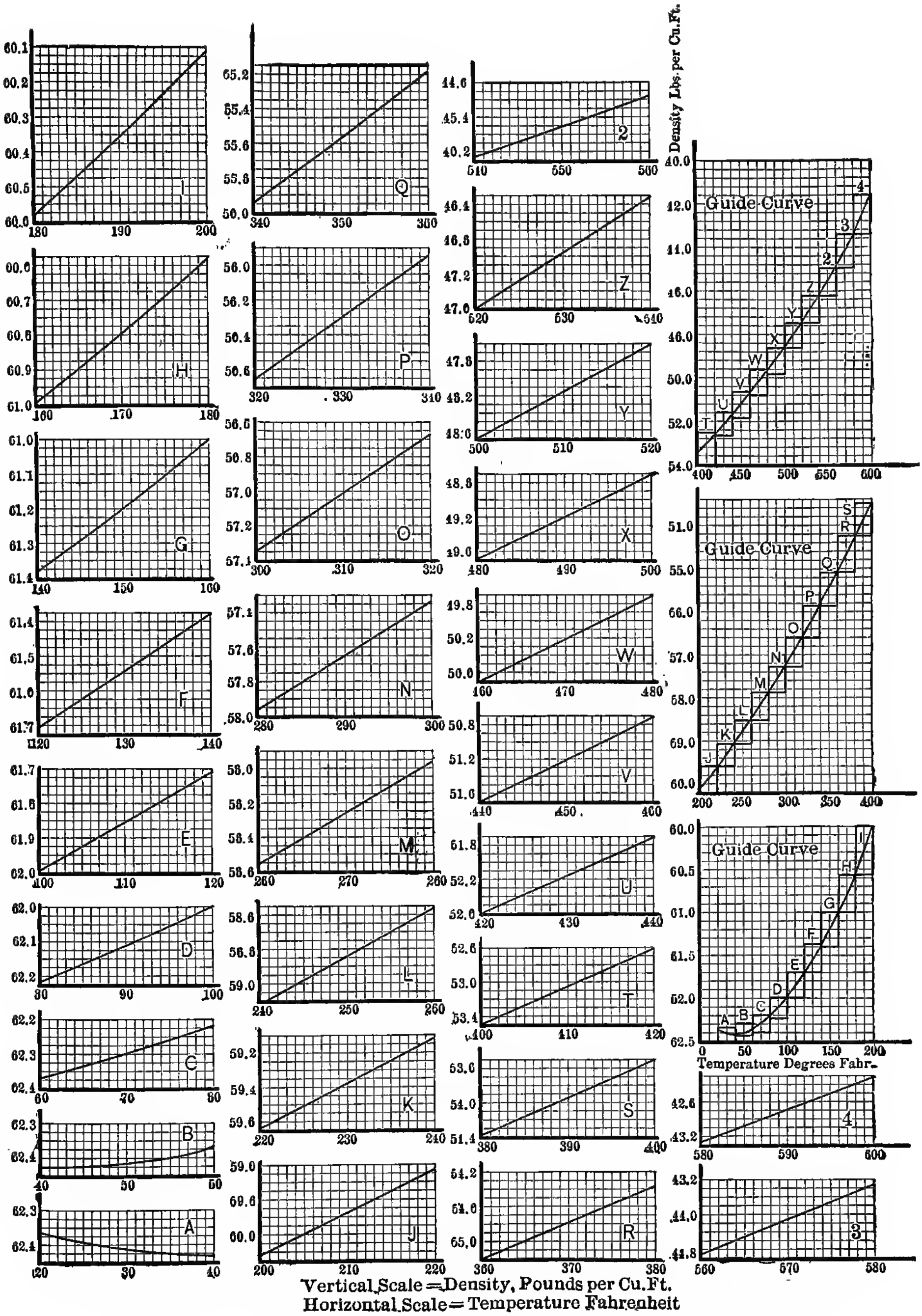


CHART 20.—Steam, Specific Volume and Density of the Liquid (Table XL).

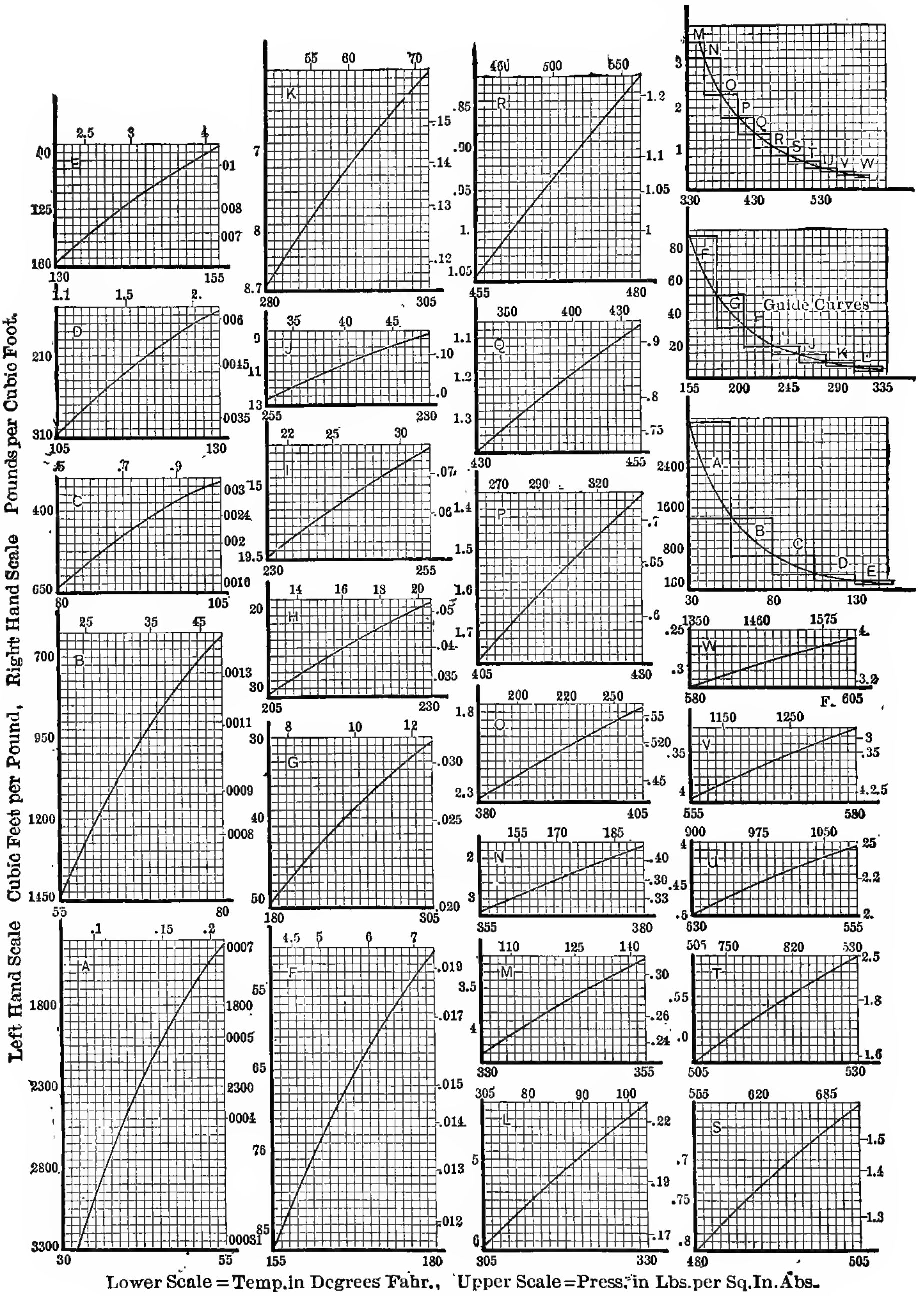


CHART 21.—Steam, Specific Volume and Density of the Vapor (Table XL).

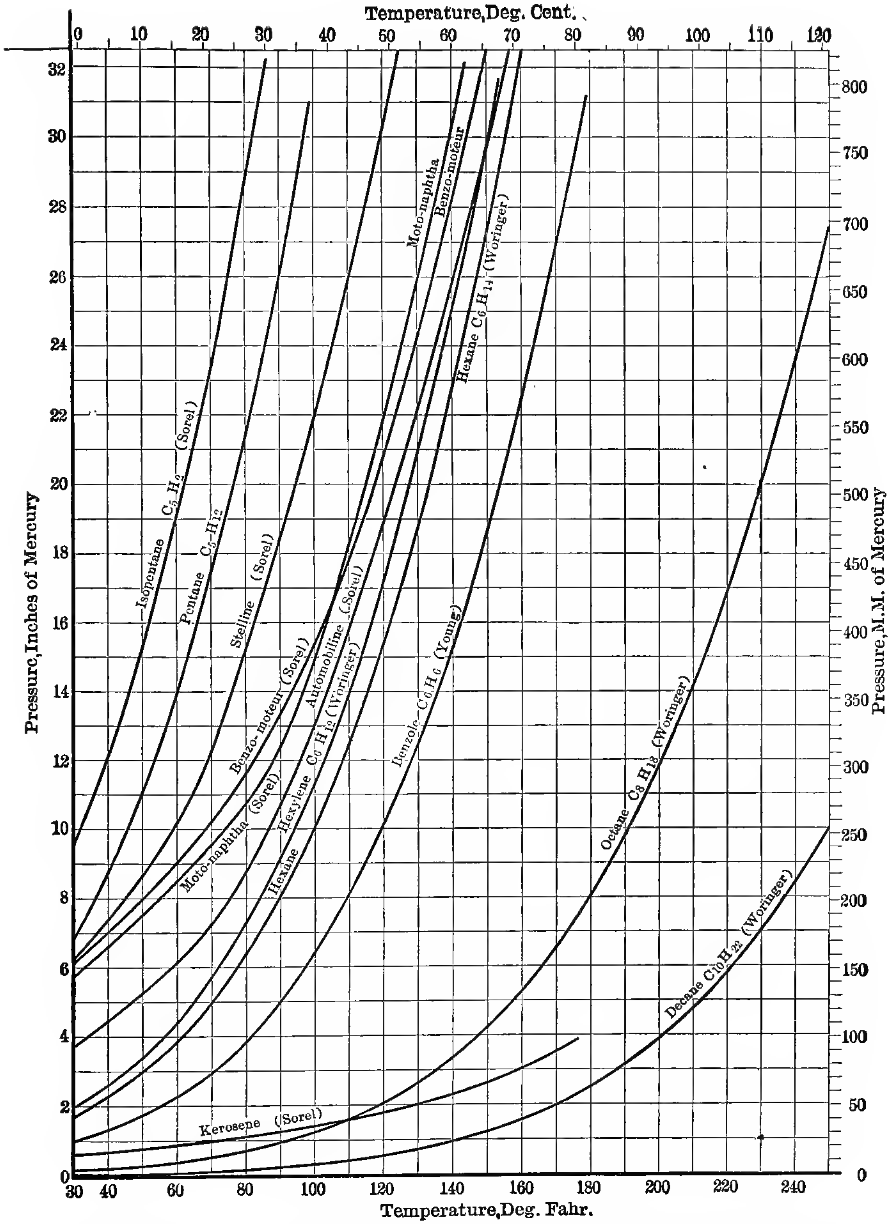


CHART 22.—Vapor Pressure of Hydrocarbons and Light Petroleum Distillates of the Gasolene Class.

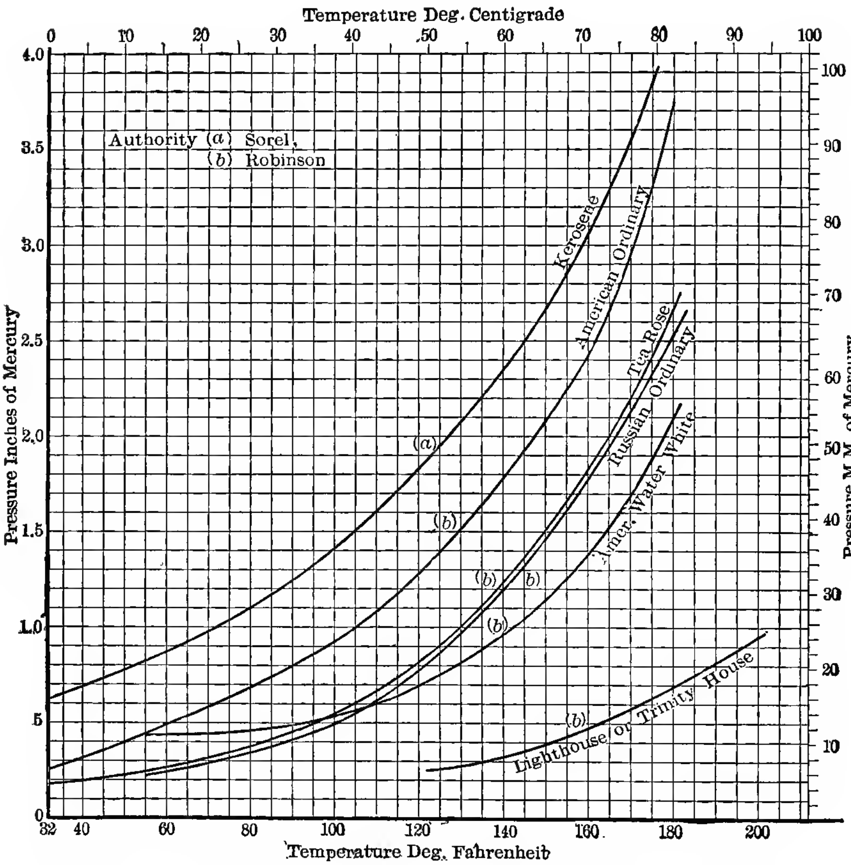


CHART 23.—Vapor Pressure of Heavy Petroleum Distillates of the Kerosene Class.

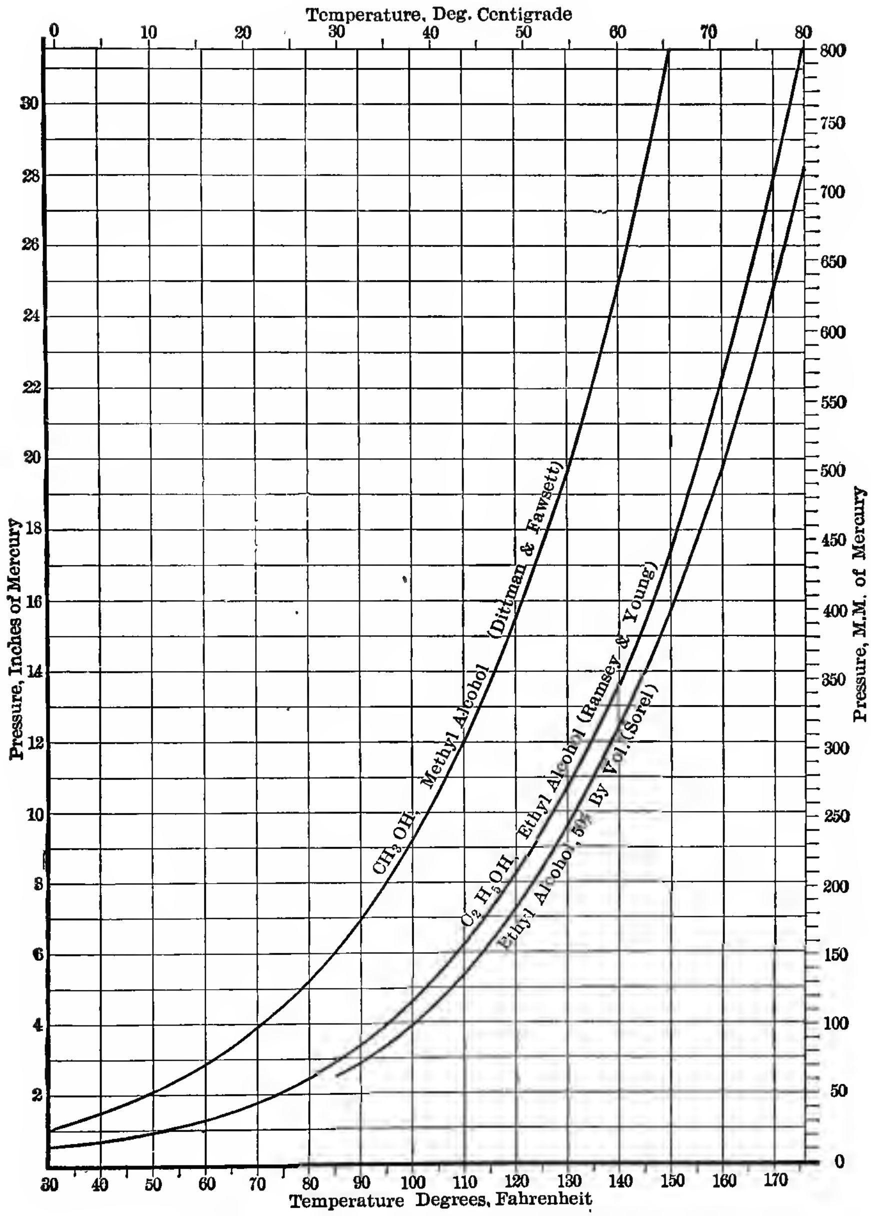


CHART 24.—Vapor Pressure of the Alcohols.

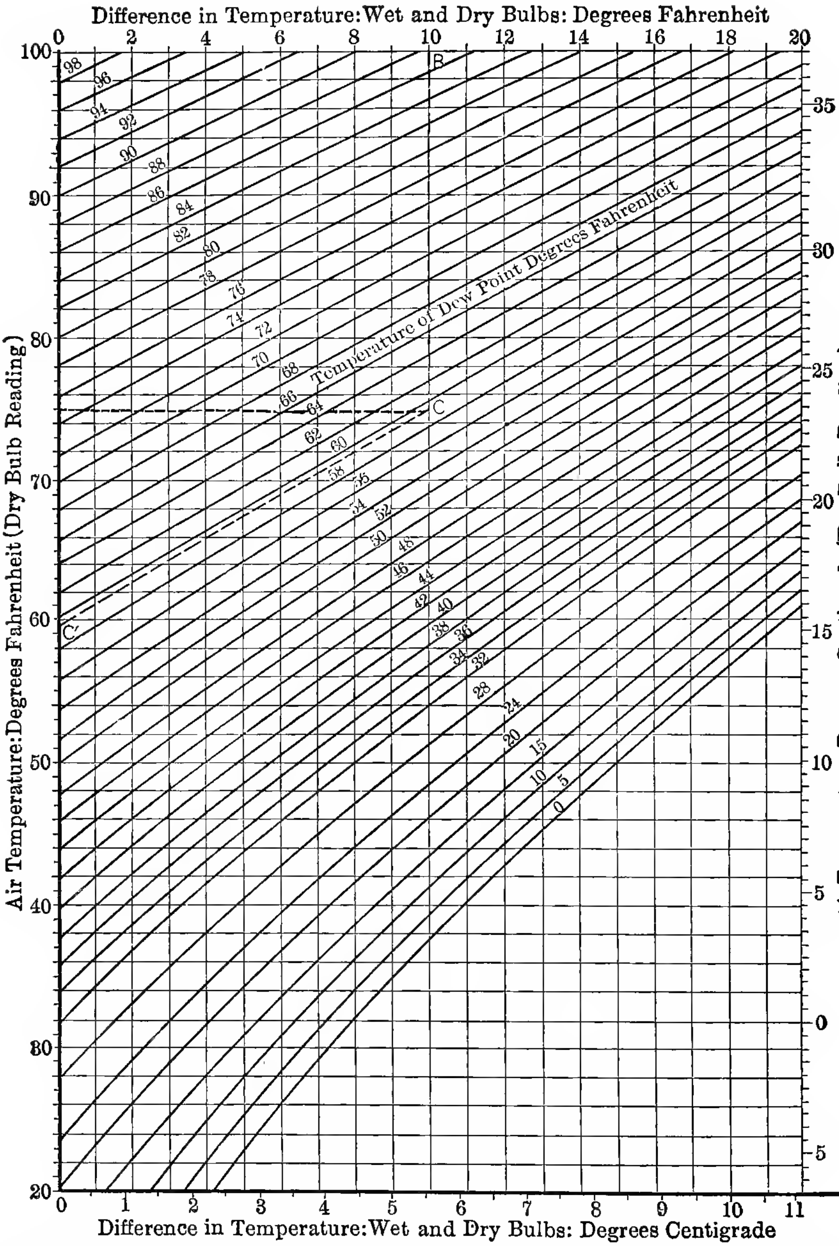


CHART 25.—Relation between Wet and Dry Bulb Psychrometer Readings and Dew Point for Air and Water Vapor.

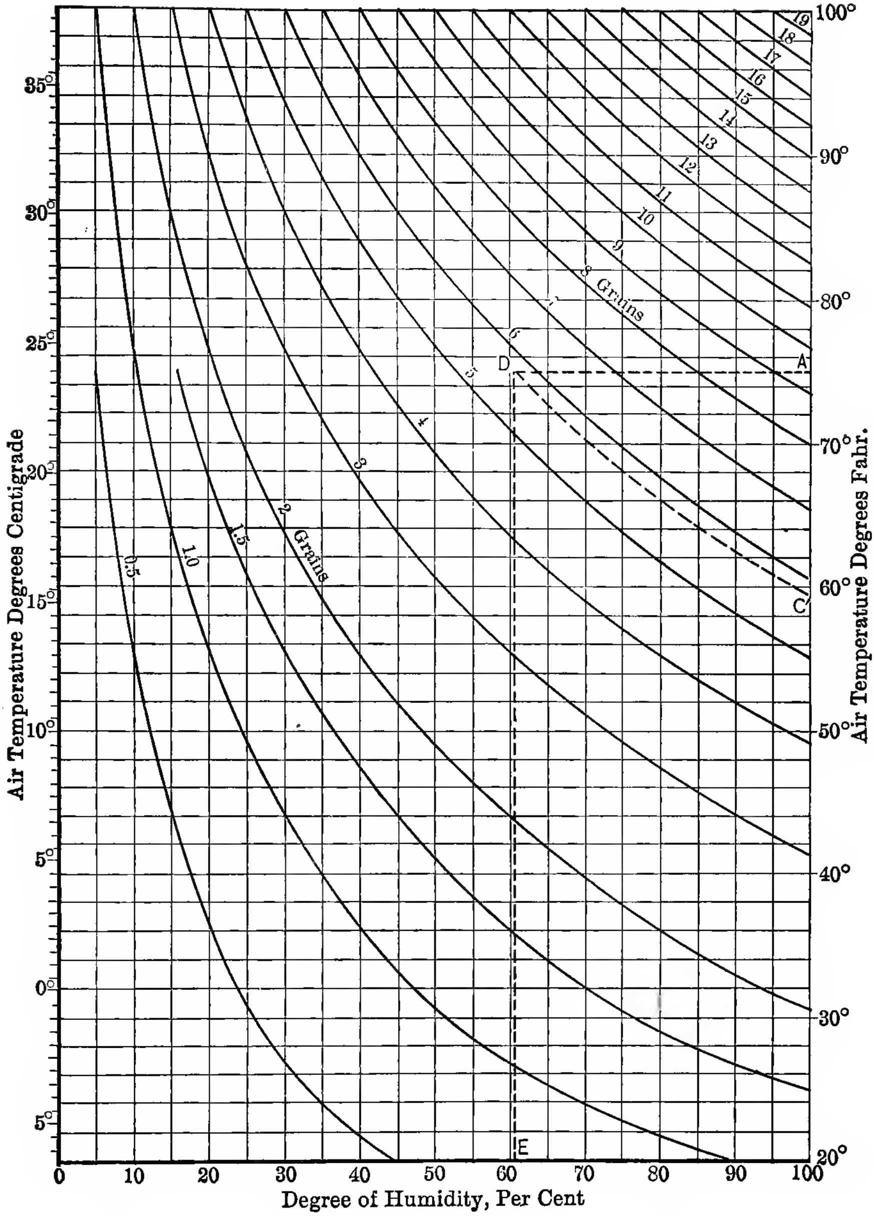


CHART 26.—Relation between Humidity and Weight of Moisture per Cubic Foot of Saturated Air.

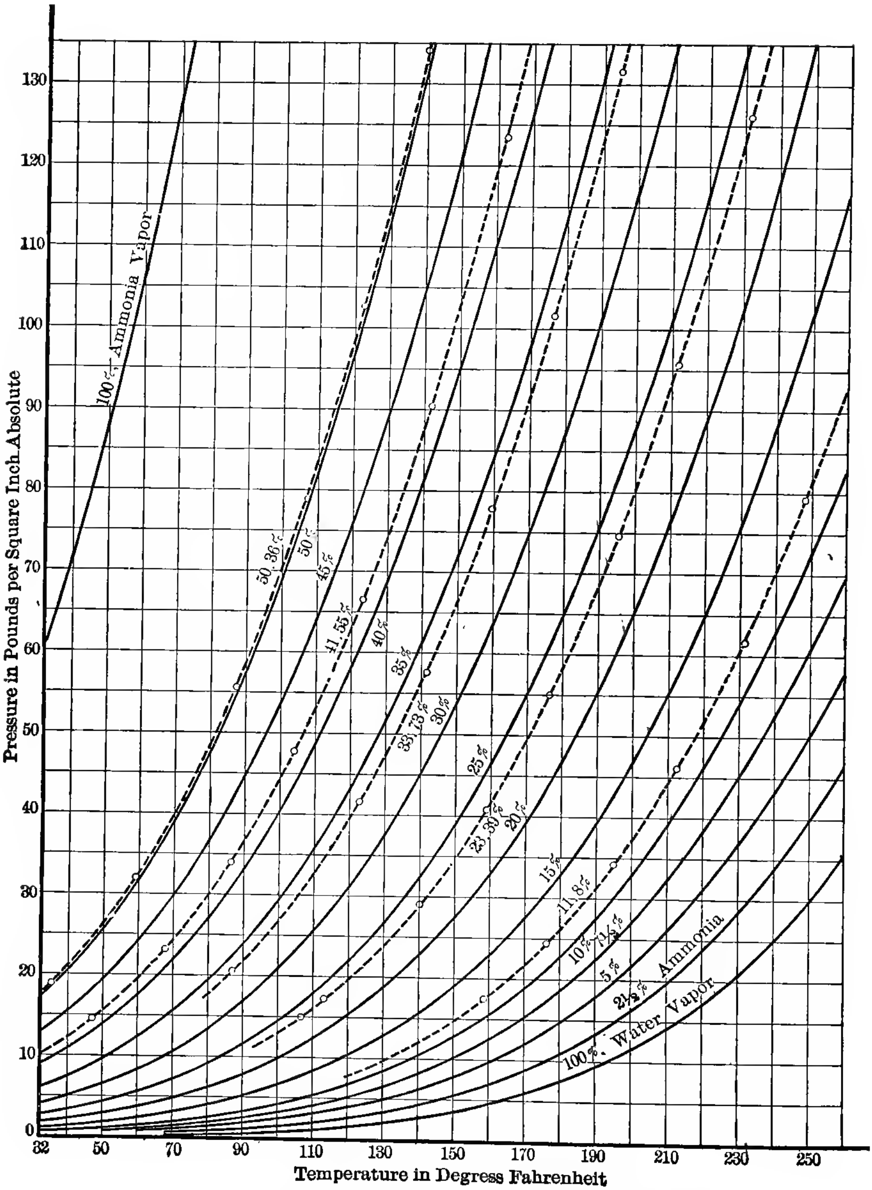


CHART 27.—Ammonia-water Solutions, Relation between Total Pressure and Temperature (Dotted Lines Mollier Data).

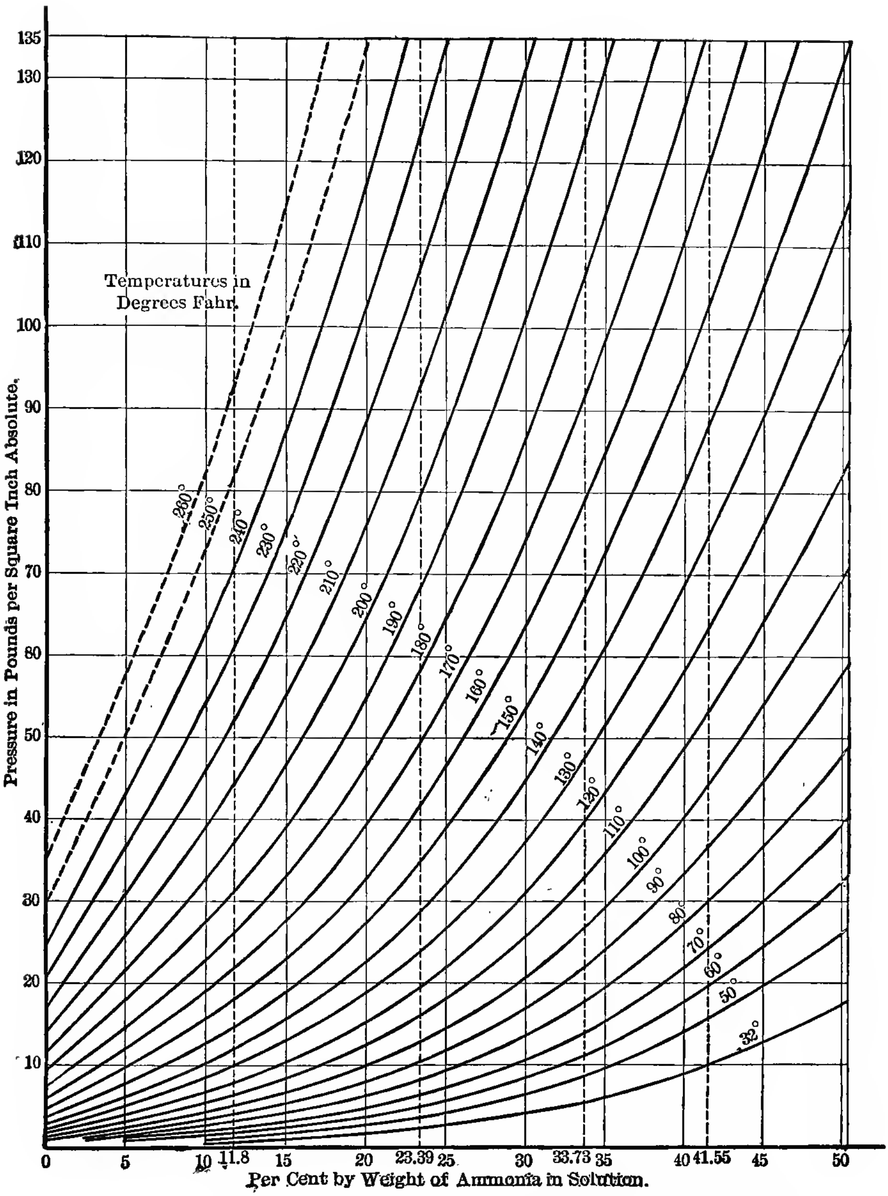


CHART 28.—Ammonia-water Solutions, Relation between Total Pressure and Per Cent NH_3 in Solution.

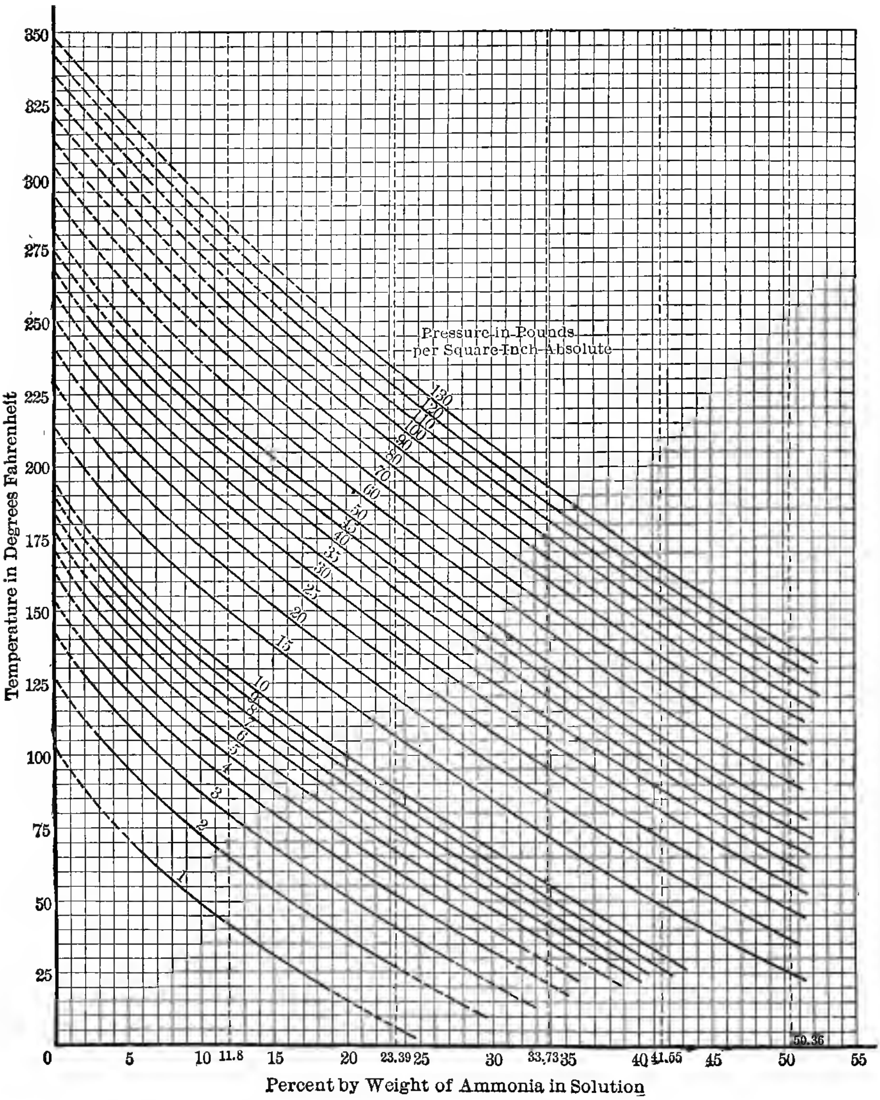


CHART 29.—Ammonia-water Solutions, Relation between Temperature and Per Cent NH_3 in Solution.

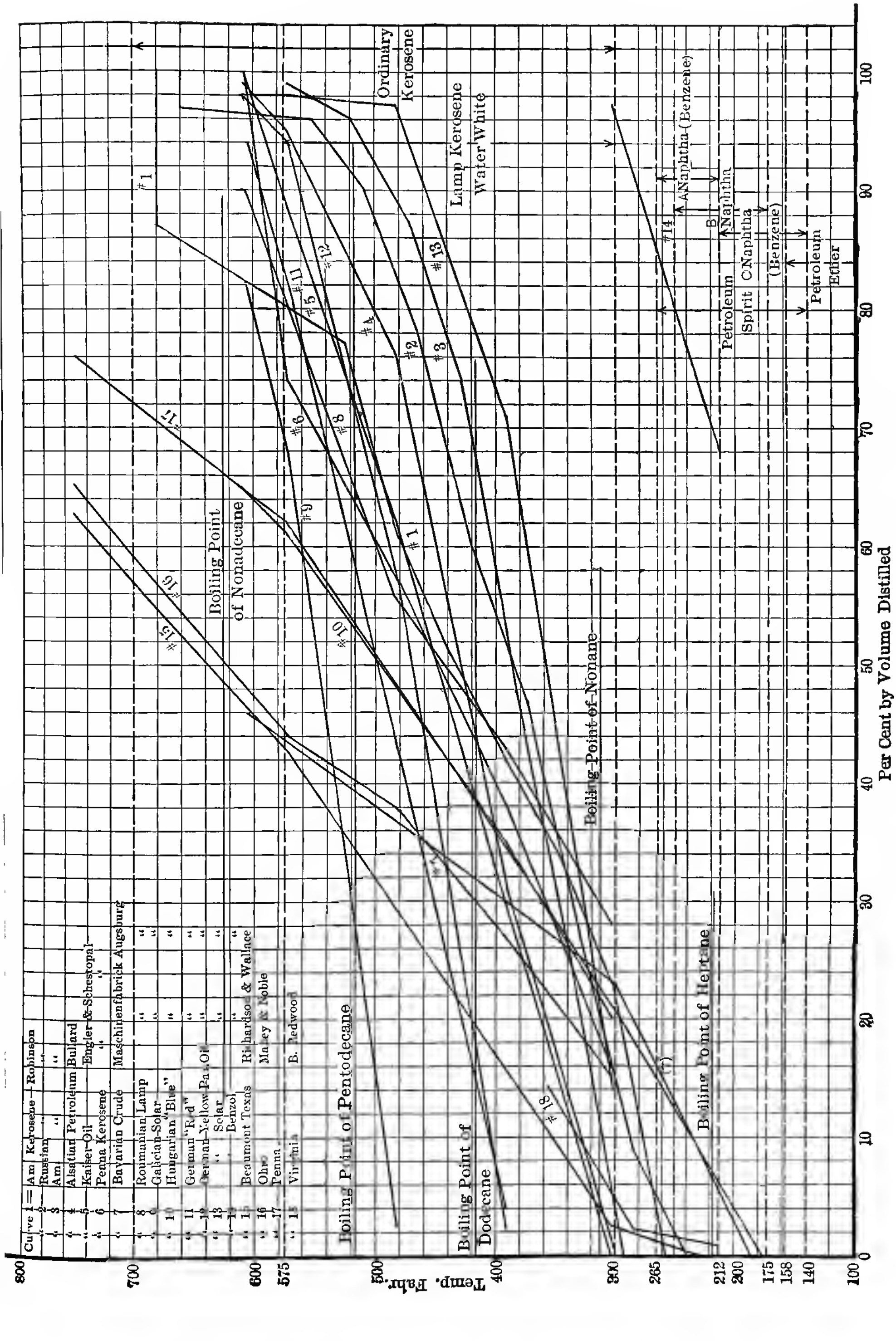


CHART 30.—Fractional Distillation of Kerosene and Petroleums.

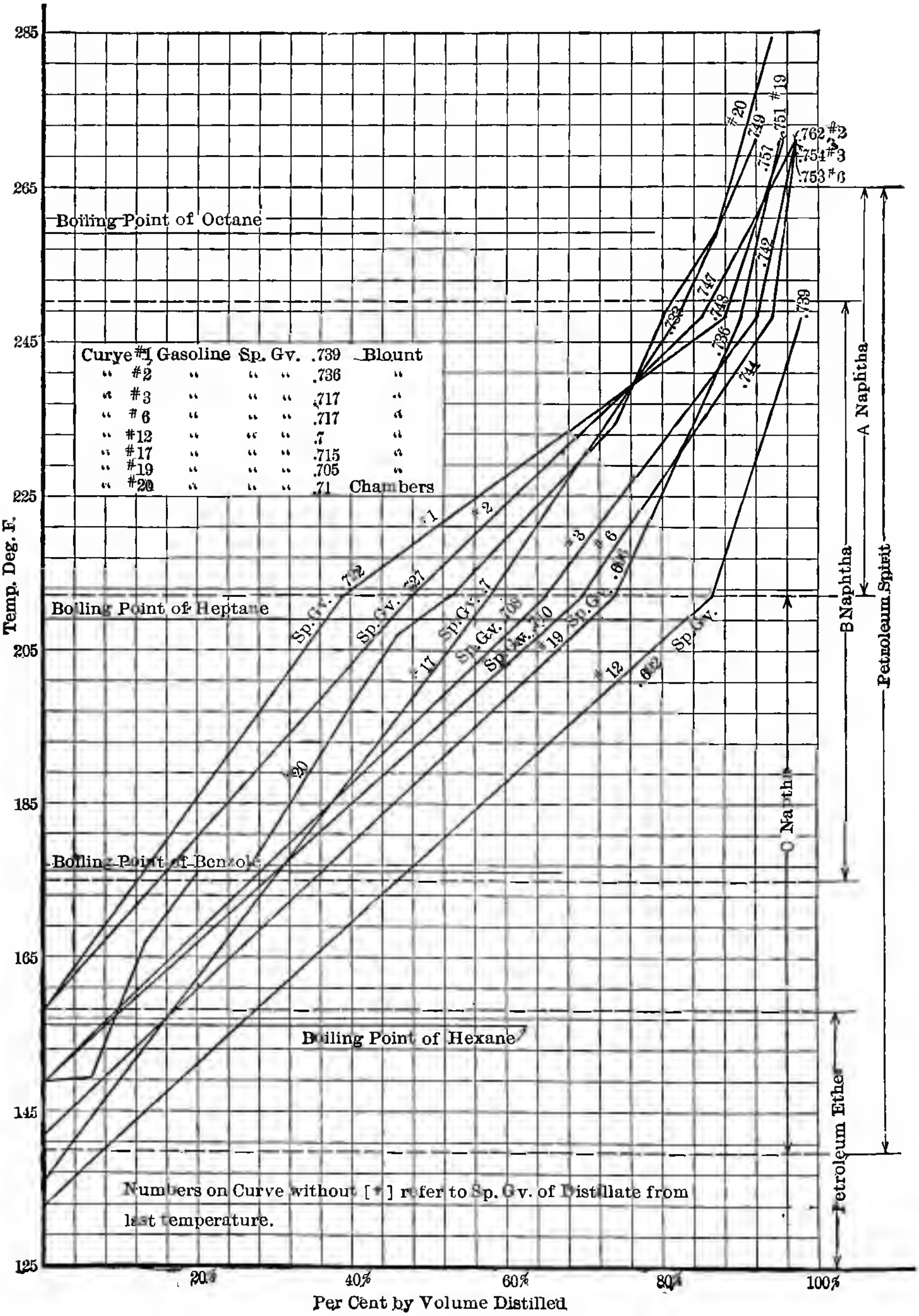


CHART 31.—Fractional Distillation of Gasolenes.

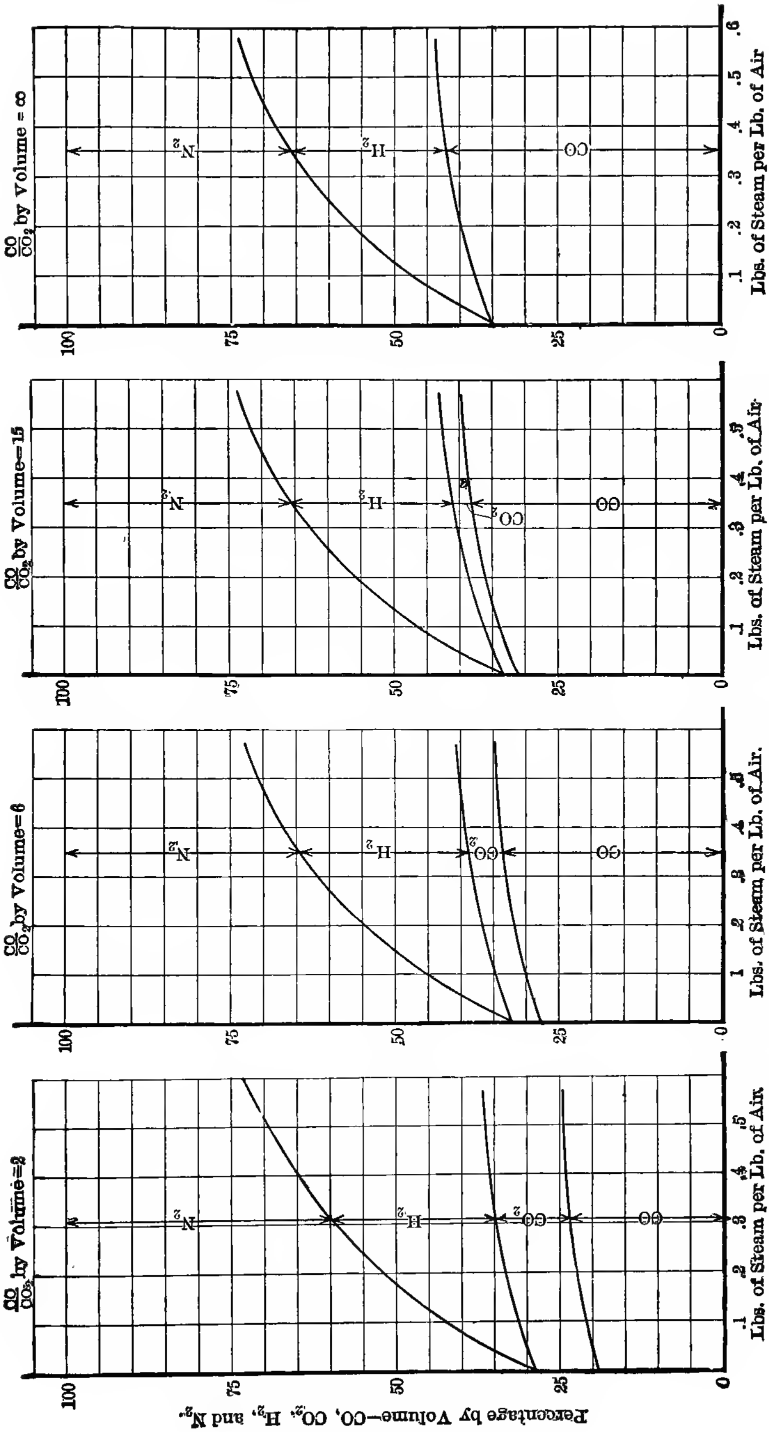


CHART 32.—Composition of Hypothetical Producer Gas from Fixed Carbon.

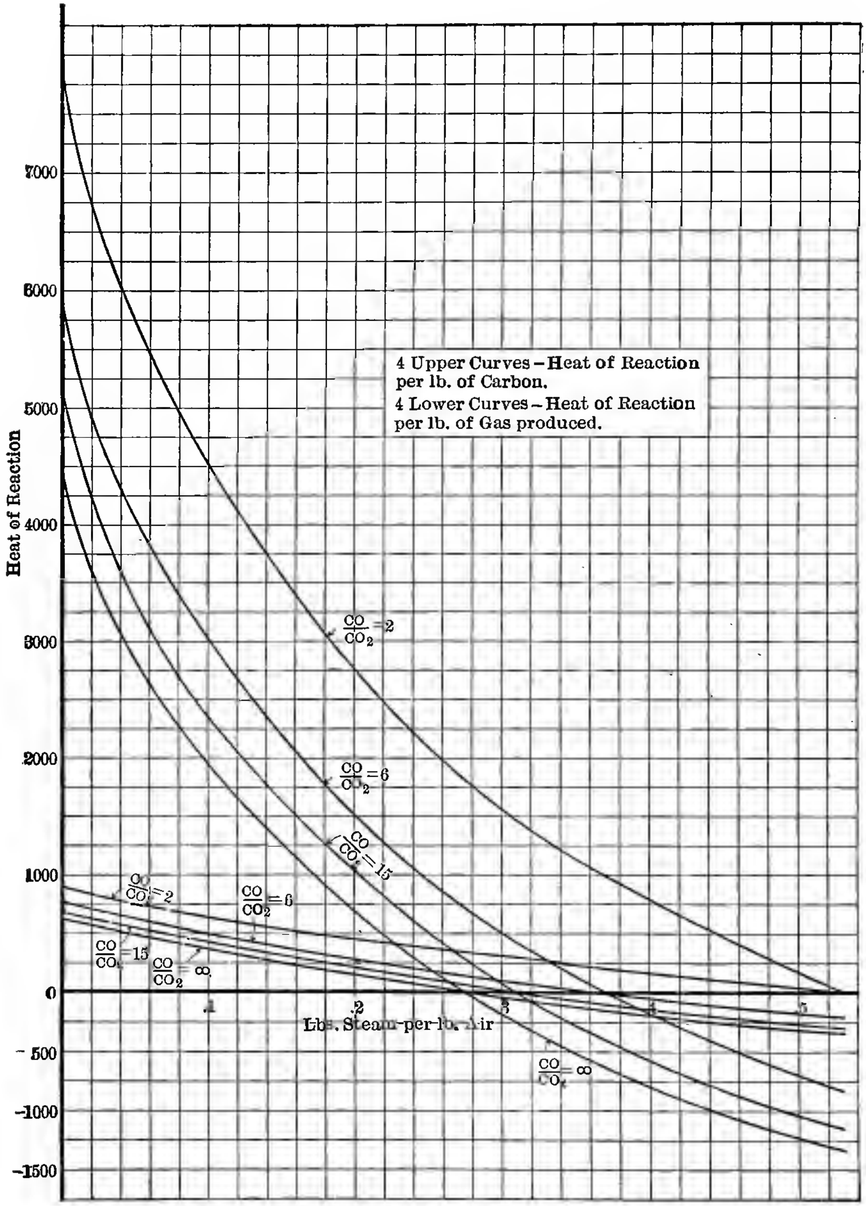


CHART 33.—Heats of Reaction for Hypothetical Producer Gas from Fixed Carbon, B. T. U.

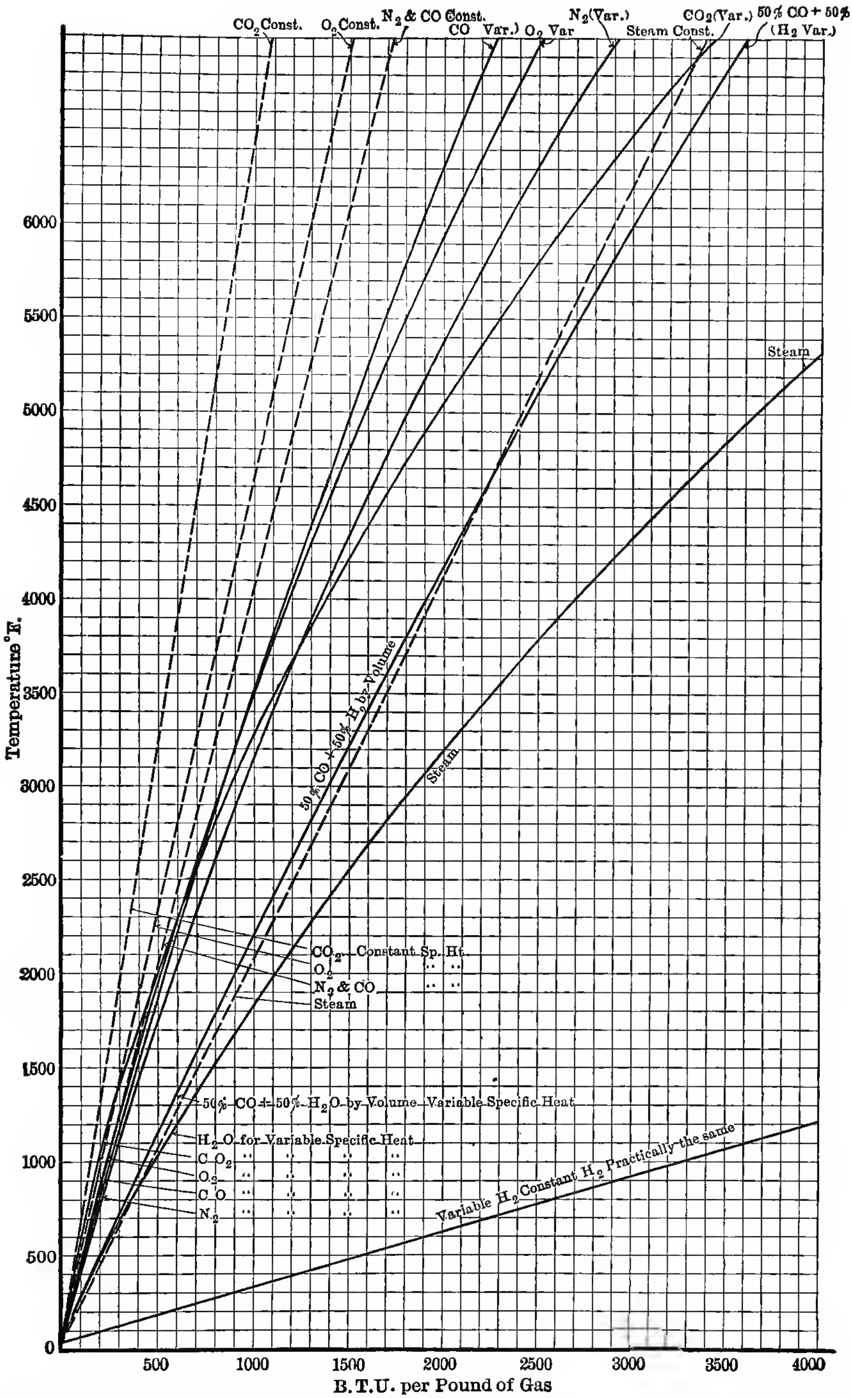


CHART 34.—Relation Between Temperatures and Heat for Gases According to the Constant and Variable Specific Heat.

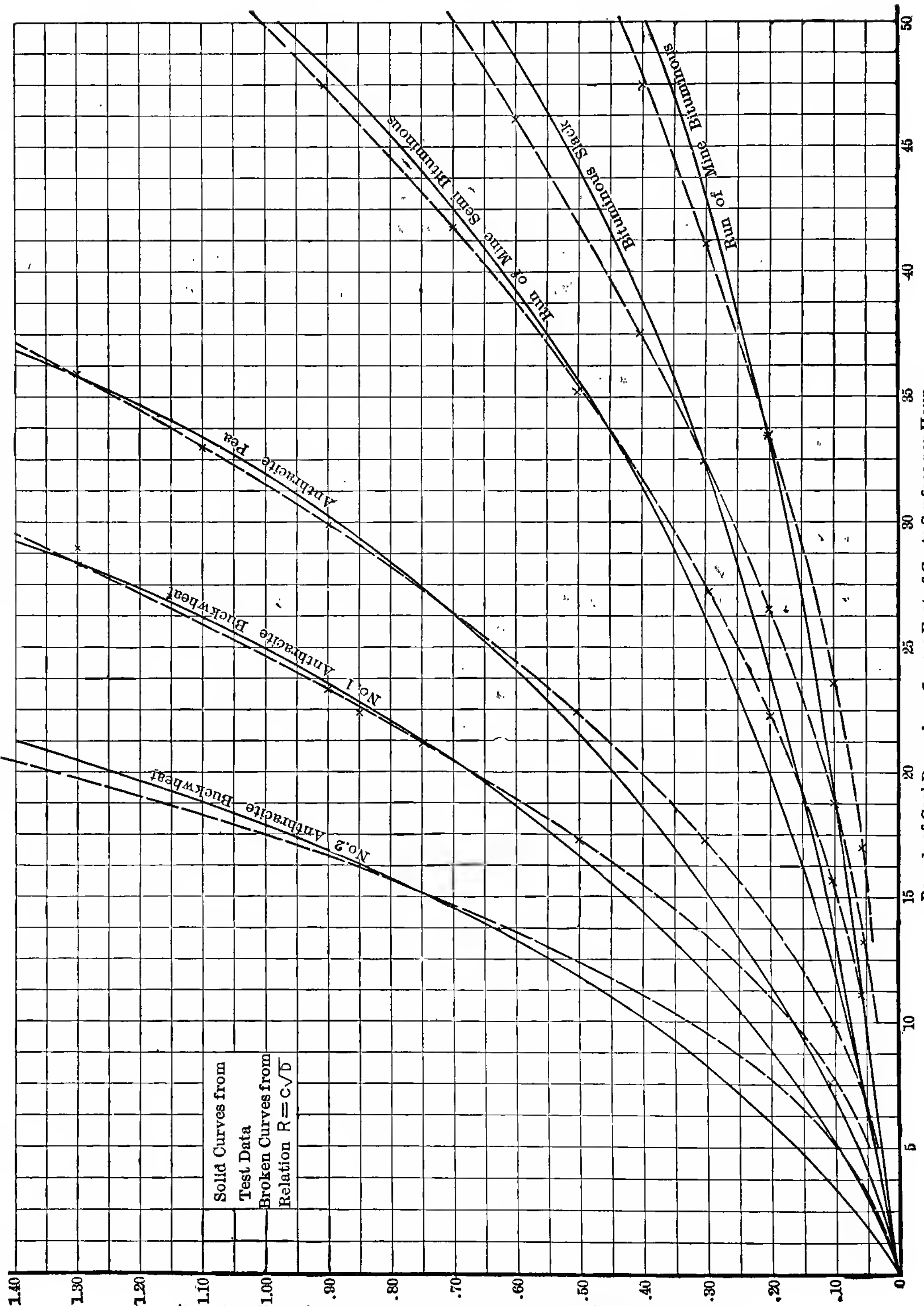


CHART 35.—Rate of Combustion of Coal with Draft.

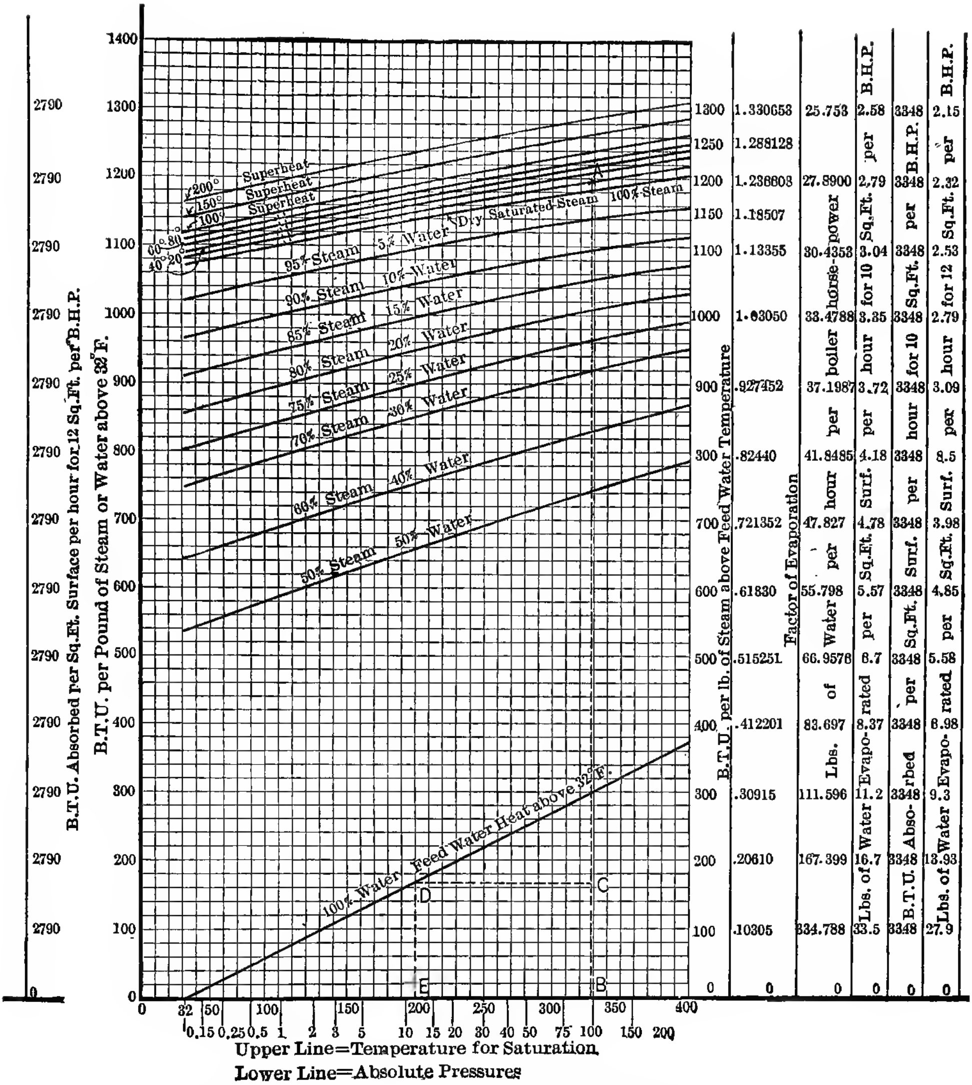


CHART 36.—Heat per Pound of Steam above Feed Temperature. Evaporation per Hour per Boiler Horse-power. Factor of Evaporation.

Each of the upper curves gives directly the total heat per pound of steam above 32° and the distance between them and the lower curve intercept, that for any feed-water temperature, by a vertical distance. If, therefore, *AB* be the total heat for the steam above 32° at 100 lbs. per sq. in. absolute and 20° superheat and *DE* the heat of liquid at 200° F. feed temperature above 32°, then *AC*, the vertical distance between these two points, is the heat per pound of steam above the feed temperature 200° F. for 100 lbs. steam with 20° superheat. This can be marked on a slip of paper and read off on the extra scale to the right in terms of, heat in B.T.U., or factor of evaporation, or actual weight of water that must be evaporated per hour to give a boiler horse-power.

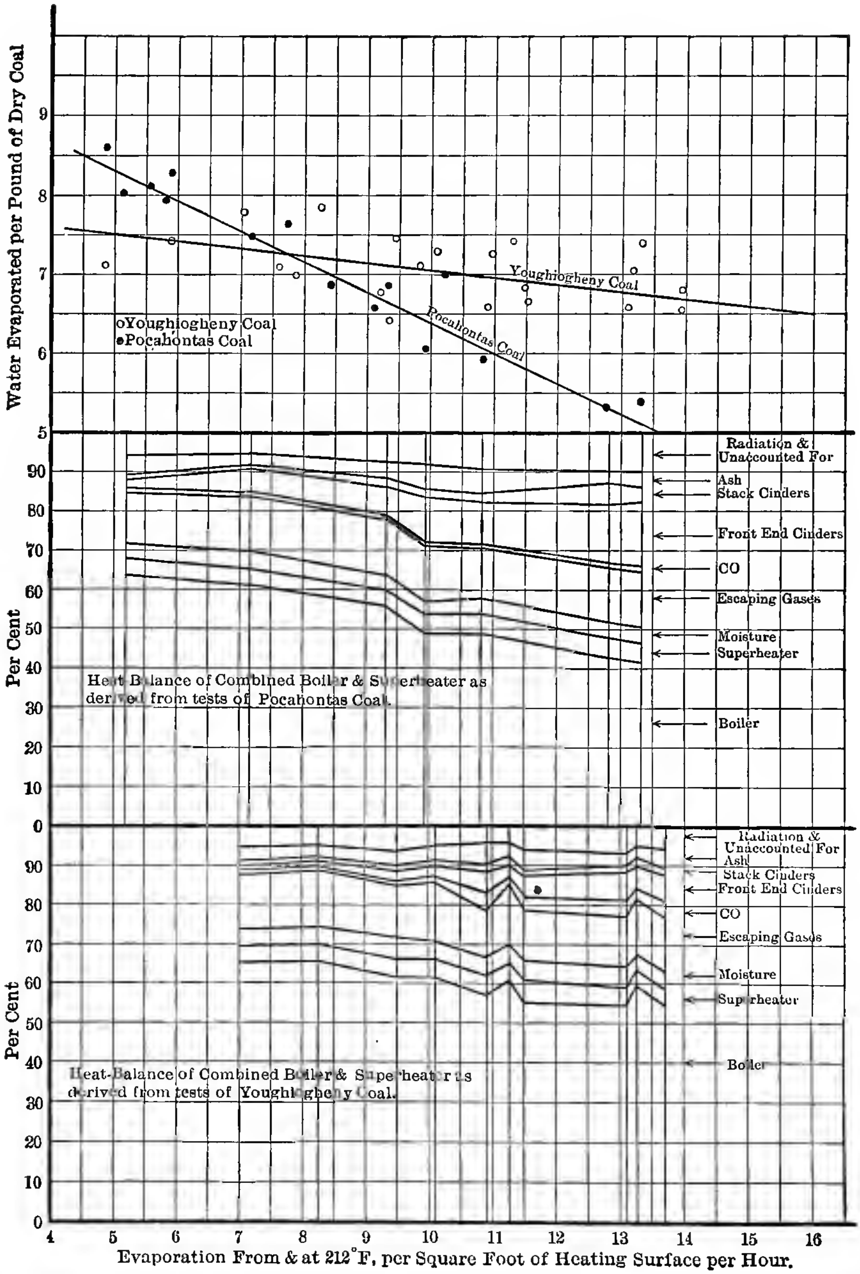


CHART 37.—Heat Balance for Locomotive Boiler Working Under Various Rates of Evaporation.

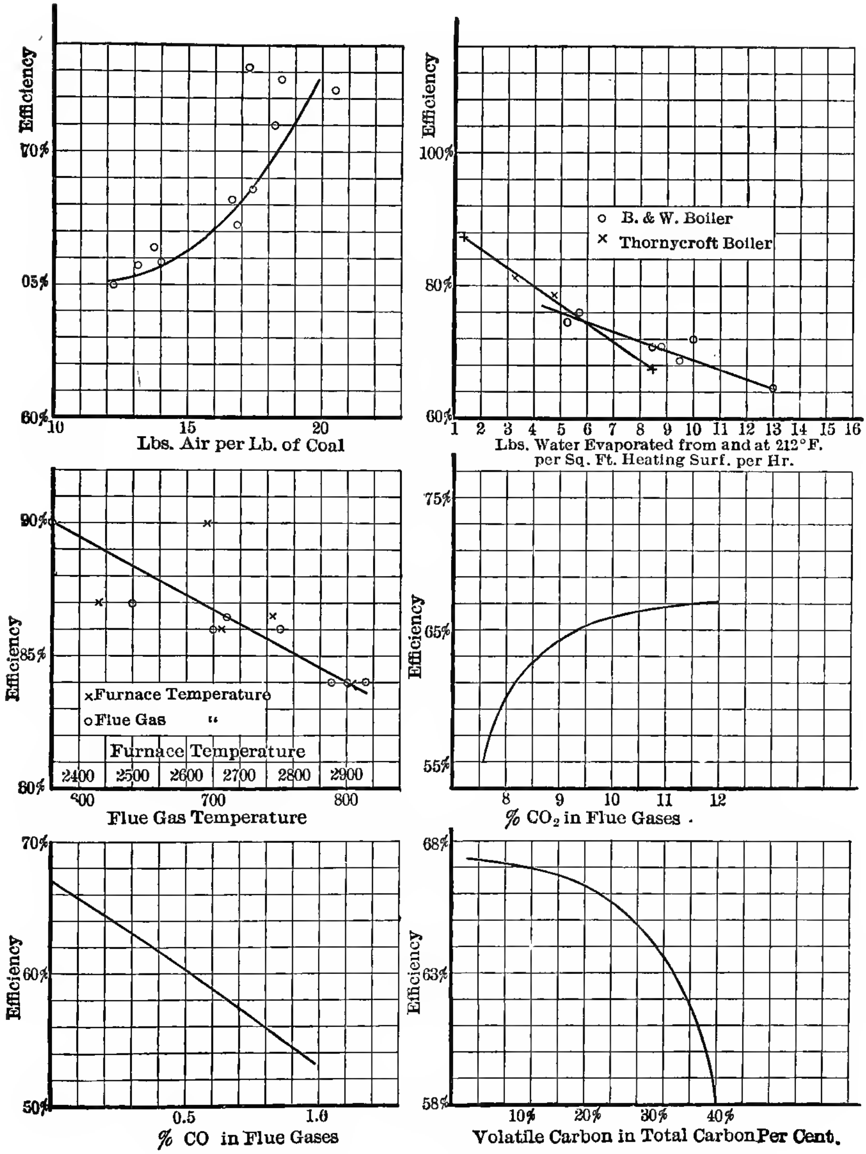


CHART 38.—Influence of Various Factors on Boiler Efficiency.

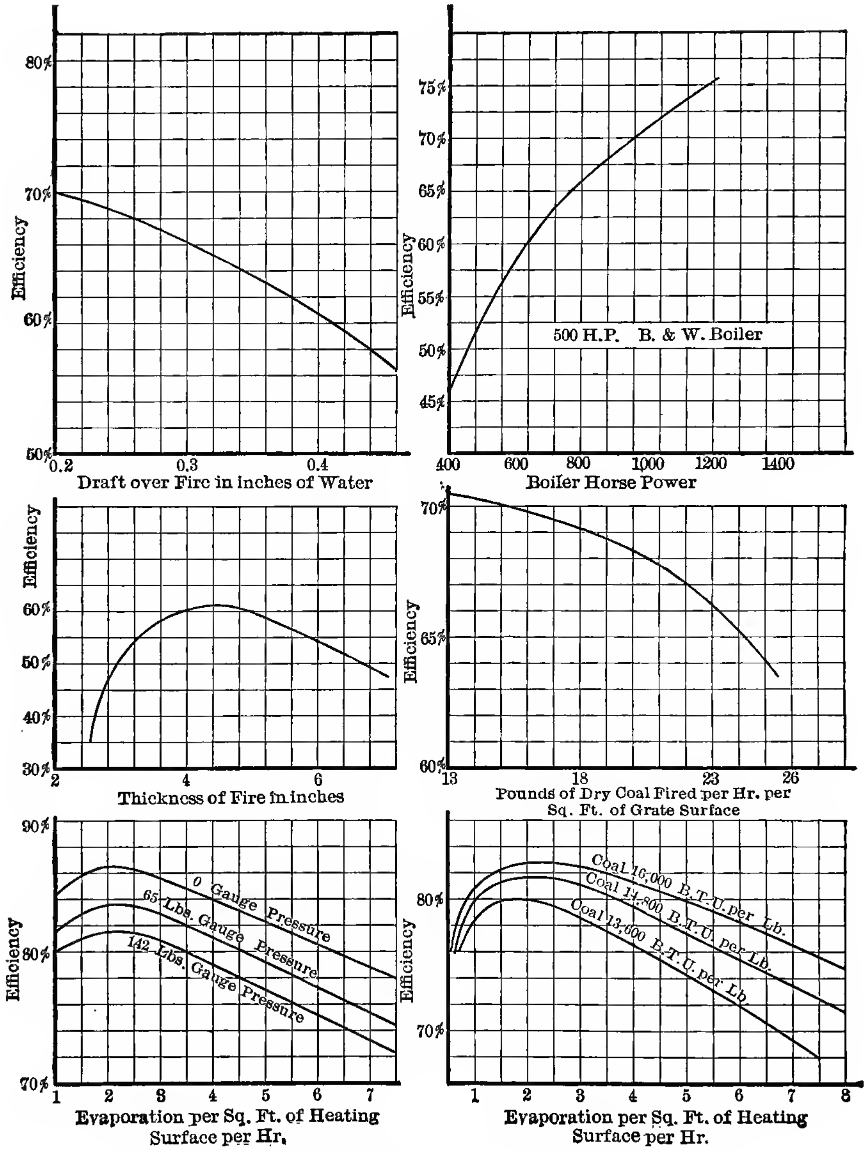


CHART 39.—Influence of Various Factors on Boiler Efficiency.

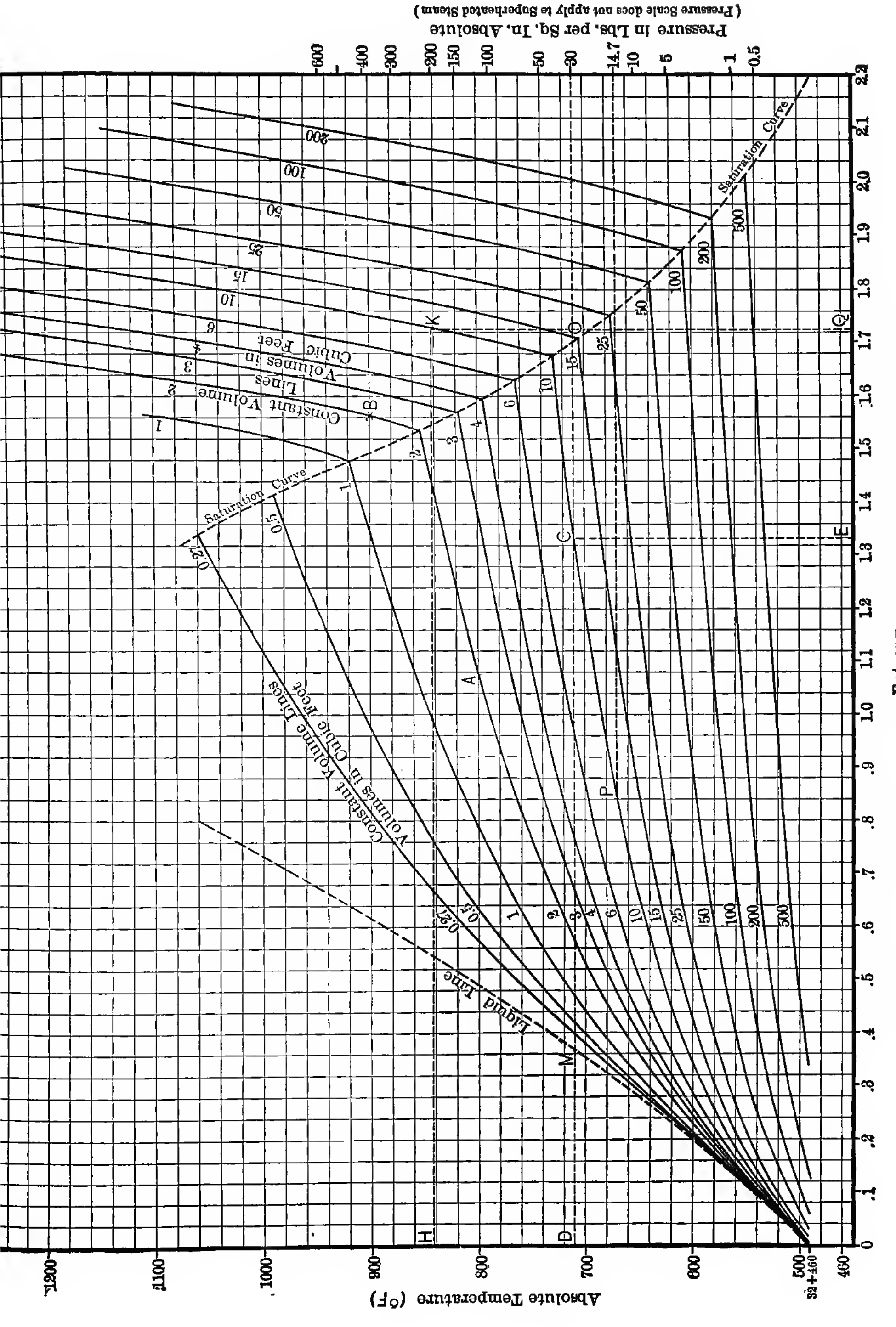


CHART 40.—Constant Volume Lines for Steam on the Temperature-entropy Diagram.

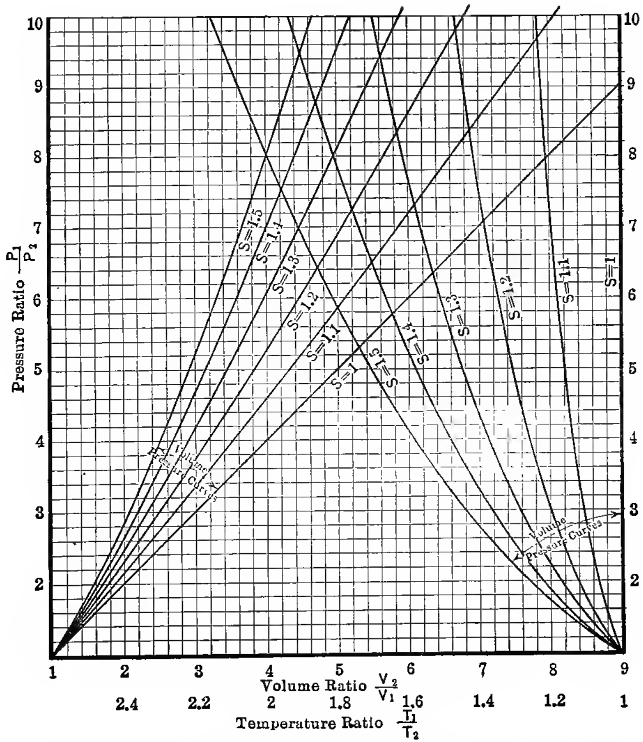


CHART 41.—Exponential Gas Changes. Relation between Initial and Final Ratio Pressures, Volumes and Temperatures for Small Pressure Ratios.

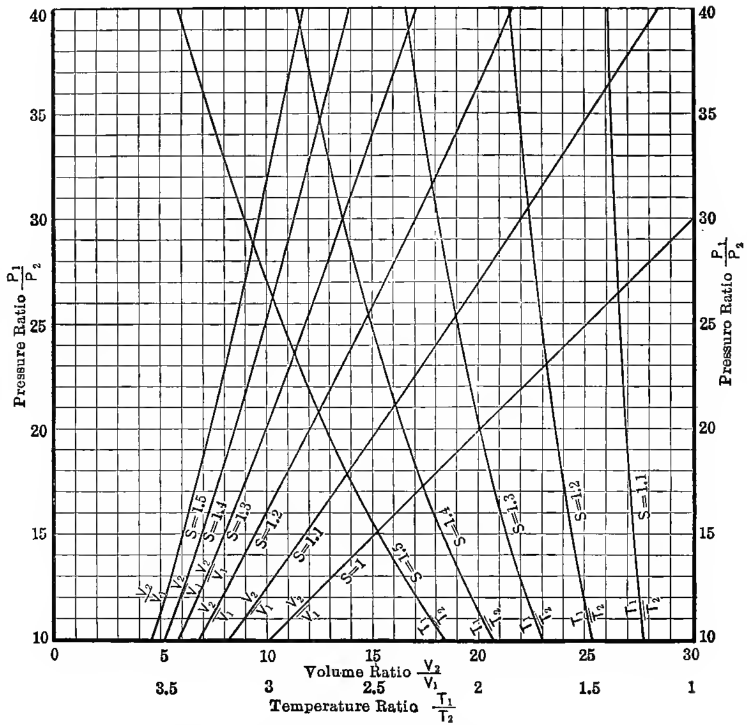


CHART 42.—Exponential Gas Changes. Relation between Initial and Final Ratios of Pressures, Volumes and Temperatures for Larger Pressure Ratios.

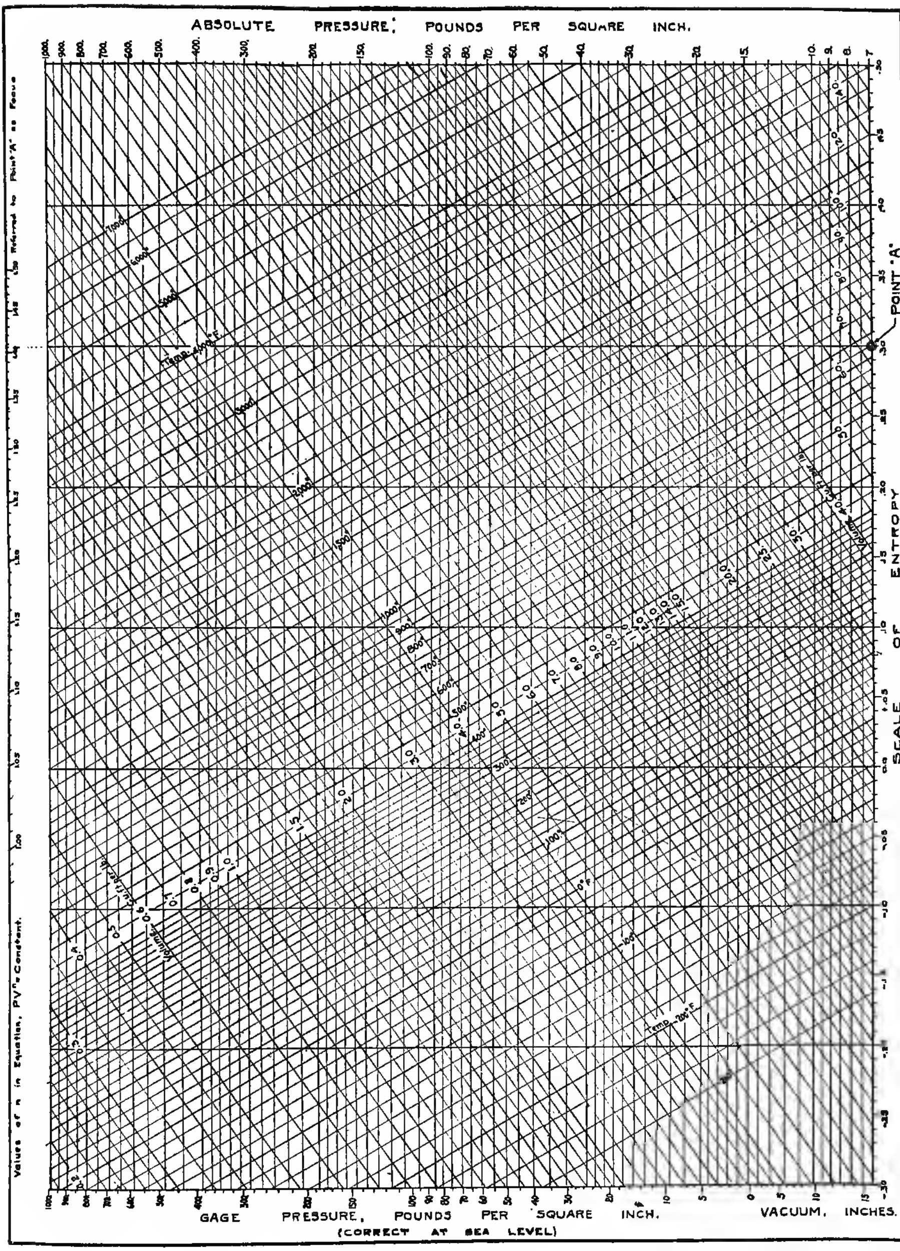


CHART 43.—Exponential Gas Changes. Relation between Initial and Final Ratios of Pressures, Volumes, Temperatures, and Entropies.

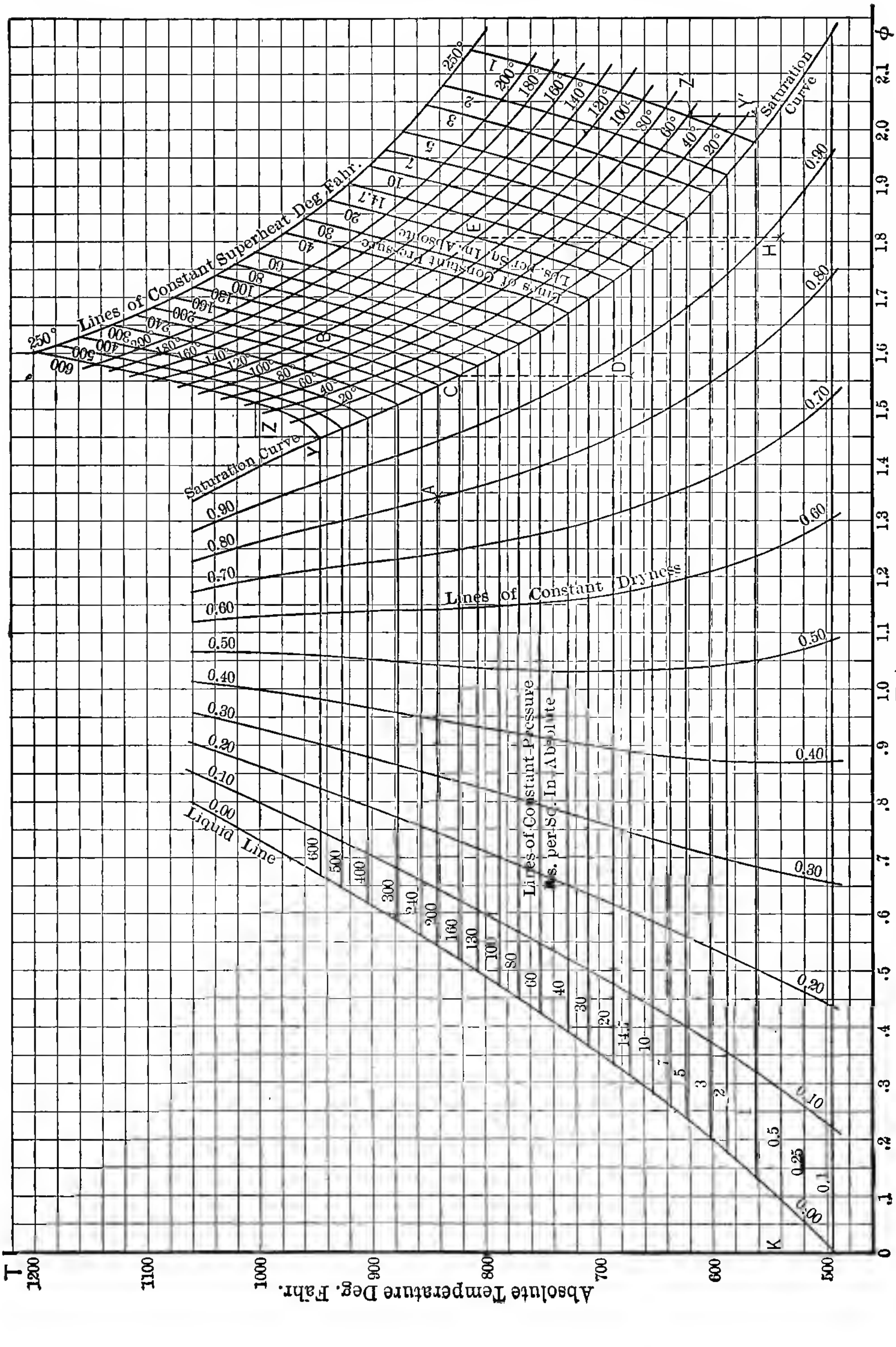


CHART 44.—Temperature-entropy Diagram with Lines of *Constant Pressure* and *Constant Quality* for Steam.

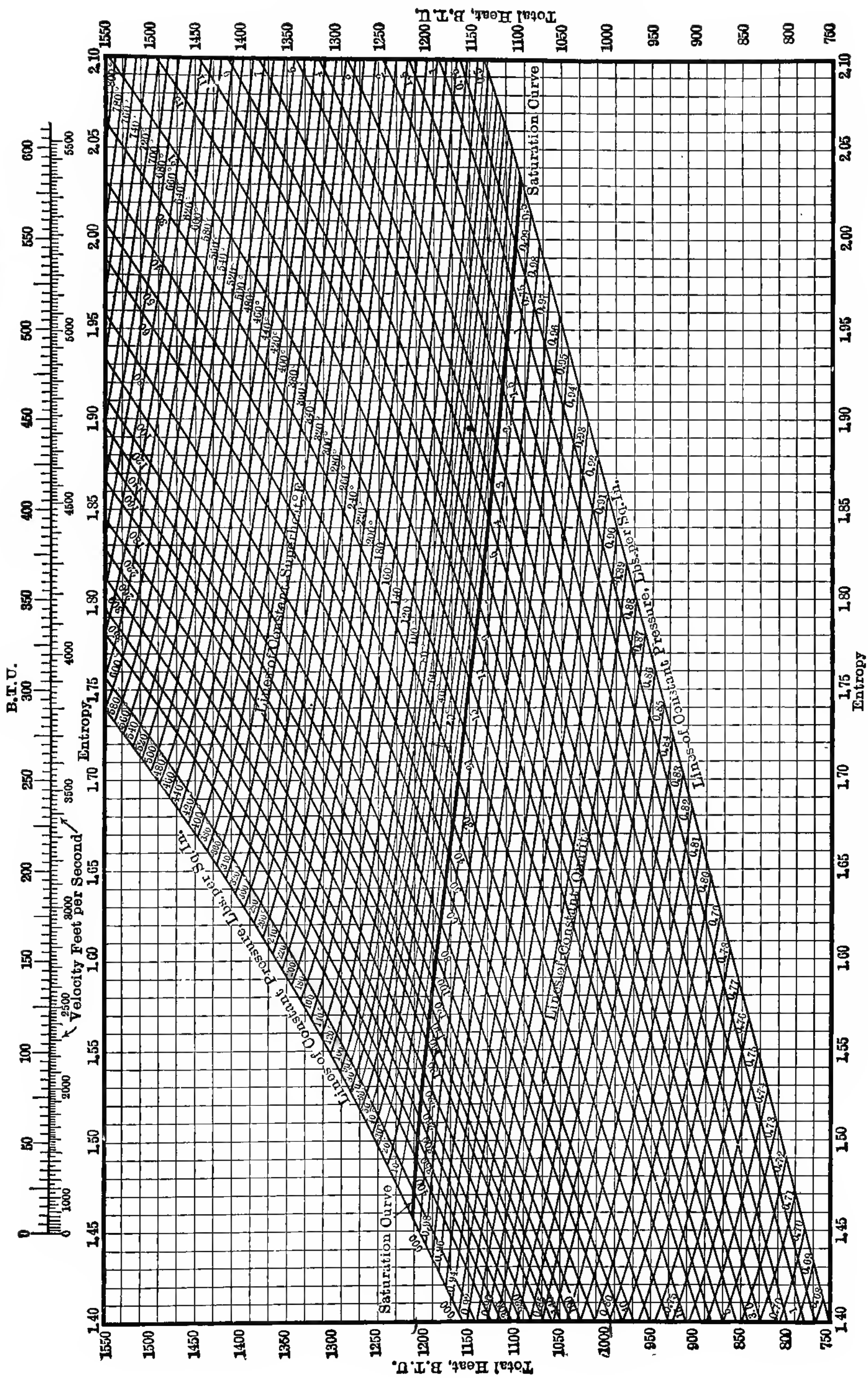


CHART 45.—The Mollier Total Heat Entropy Diagram for Steam.

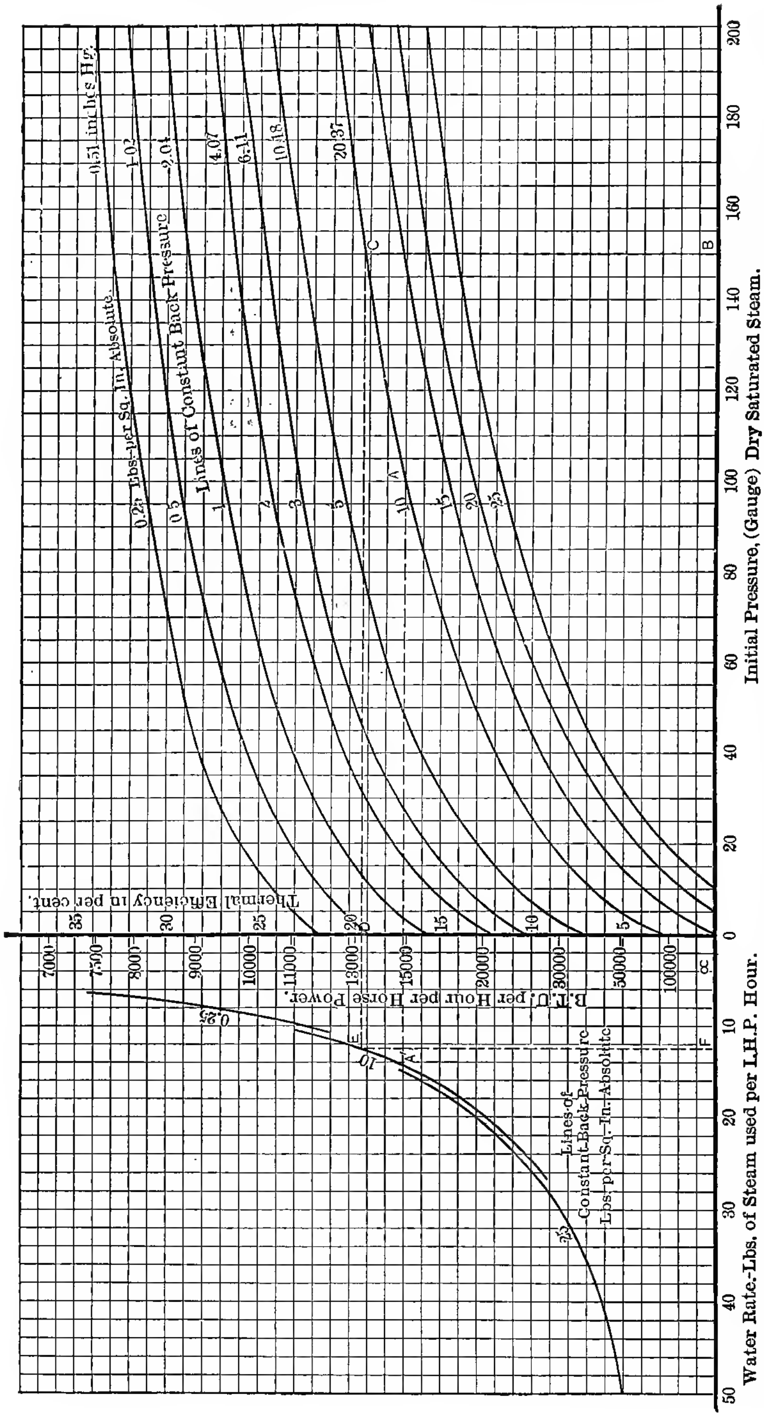


CHART 46.—Rankine Cycle, Thermal Efficiency, Heat Consumption per Hour per Horse-power and Water Rate, for Various Back Pressures and any Initial Pressure. Steam Initially Dry and Saturated.

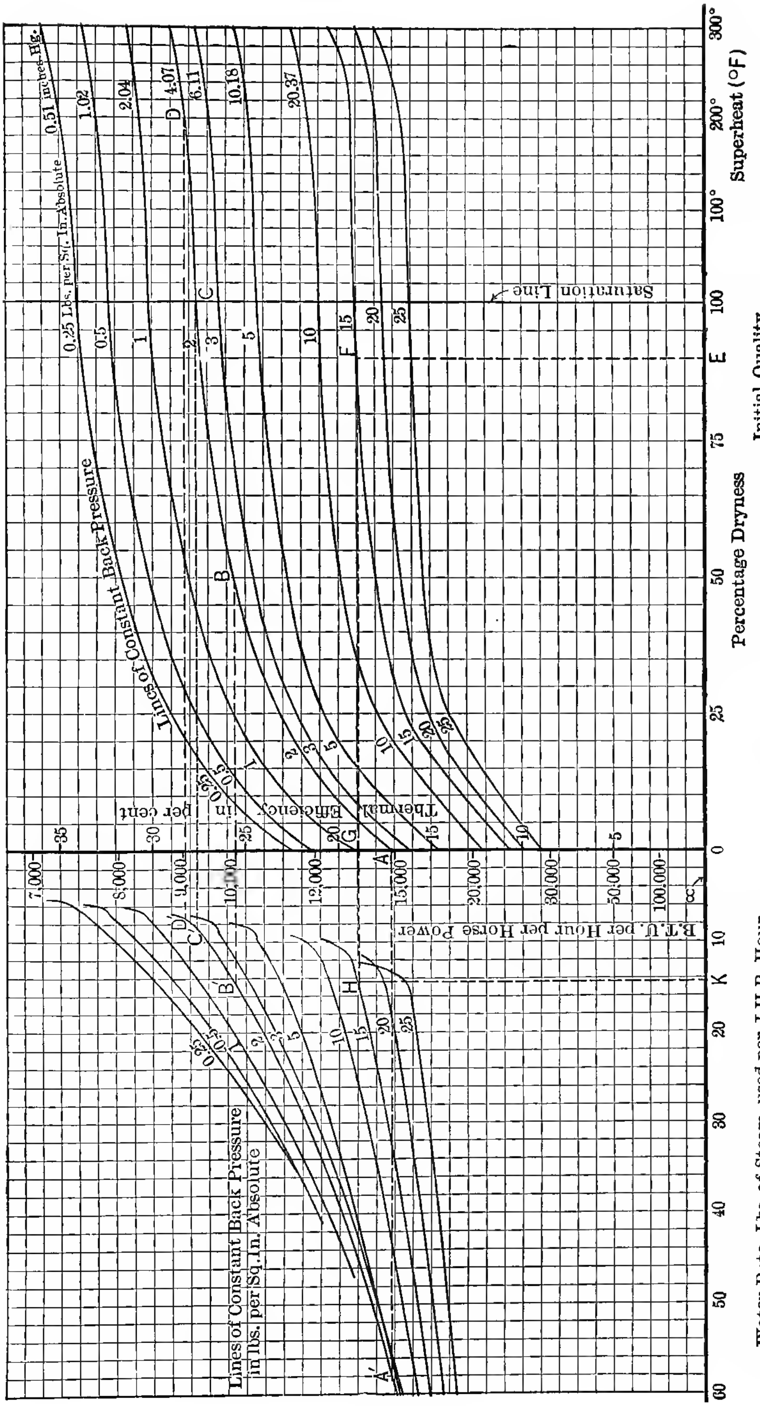


CHART 47.—Rankine Cycle, Thermal Efficiency, Heat Consumption per Hour per Horse-power and Water Rate, for 200 lbs. per sq. in. gage Initial Pressure and Various Back Pressures, Steam Initially of any Quality.

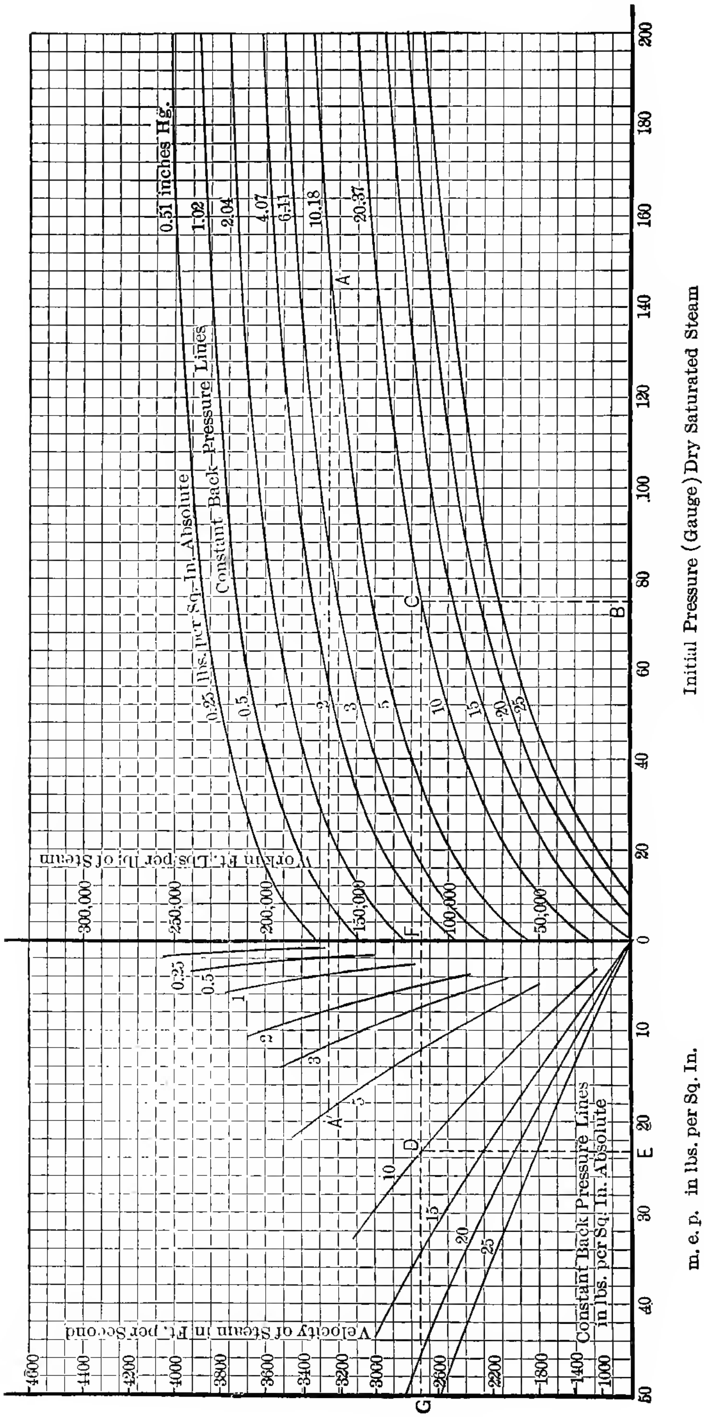


CHART 48.—Rankine Cycle. Work per lb. of Steam, (m.e.p.), and Jet Velocity for Various Back Pressures, and any Initial Pressure Steam Initially Dry Saturated.

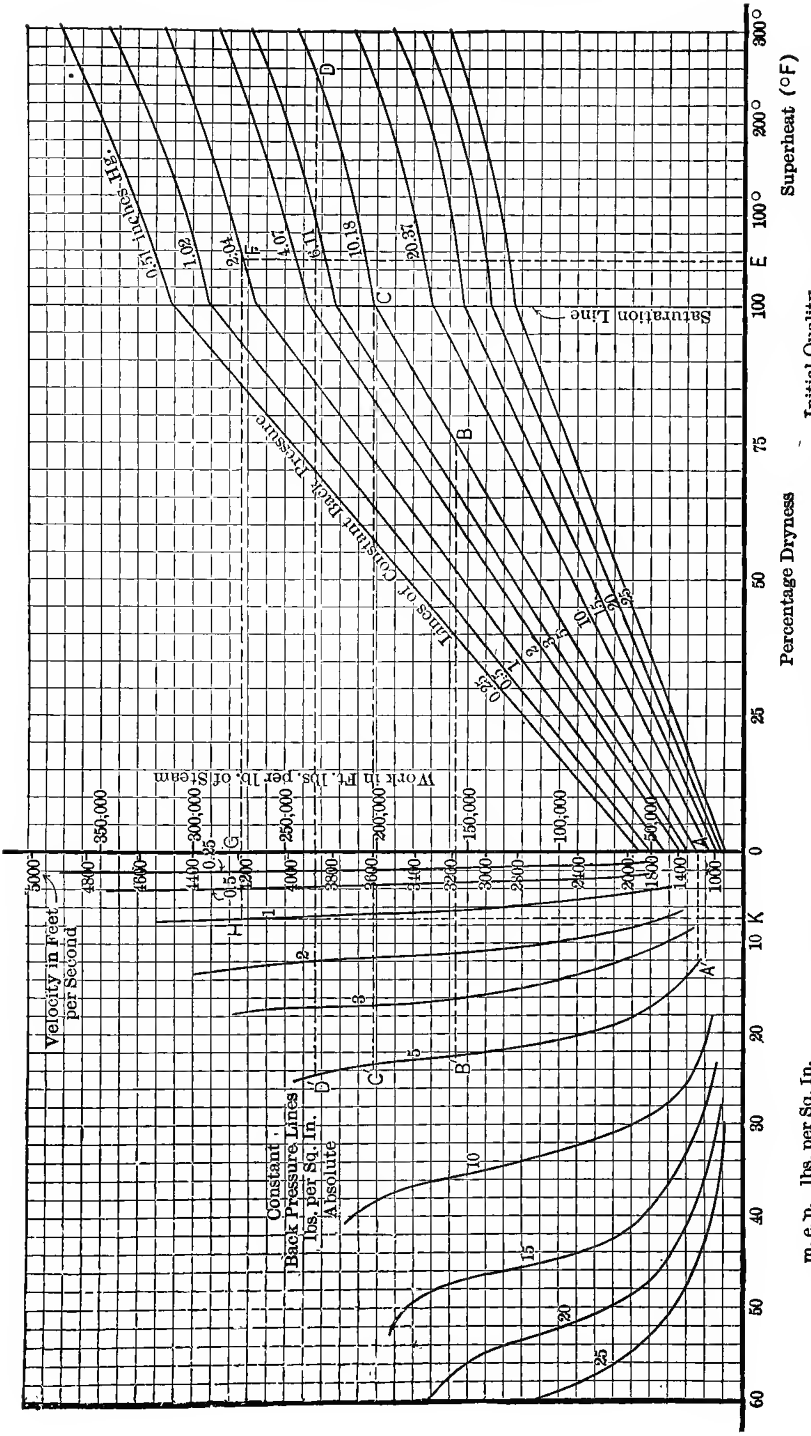


CHART 49.—Rankine Cycle. Work per lb. of Steam (m.e.p.) and Jet Velocity for 200 lbs. per sq. in. gage Initial Pressure and Various Back Pressures, Steam Initial of any Quality.

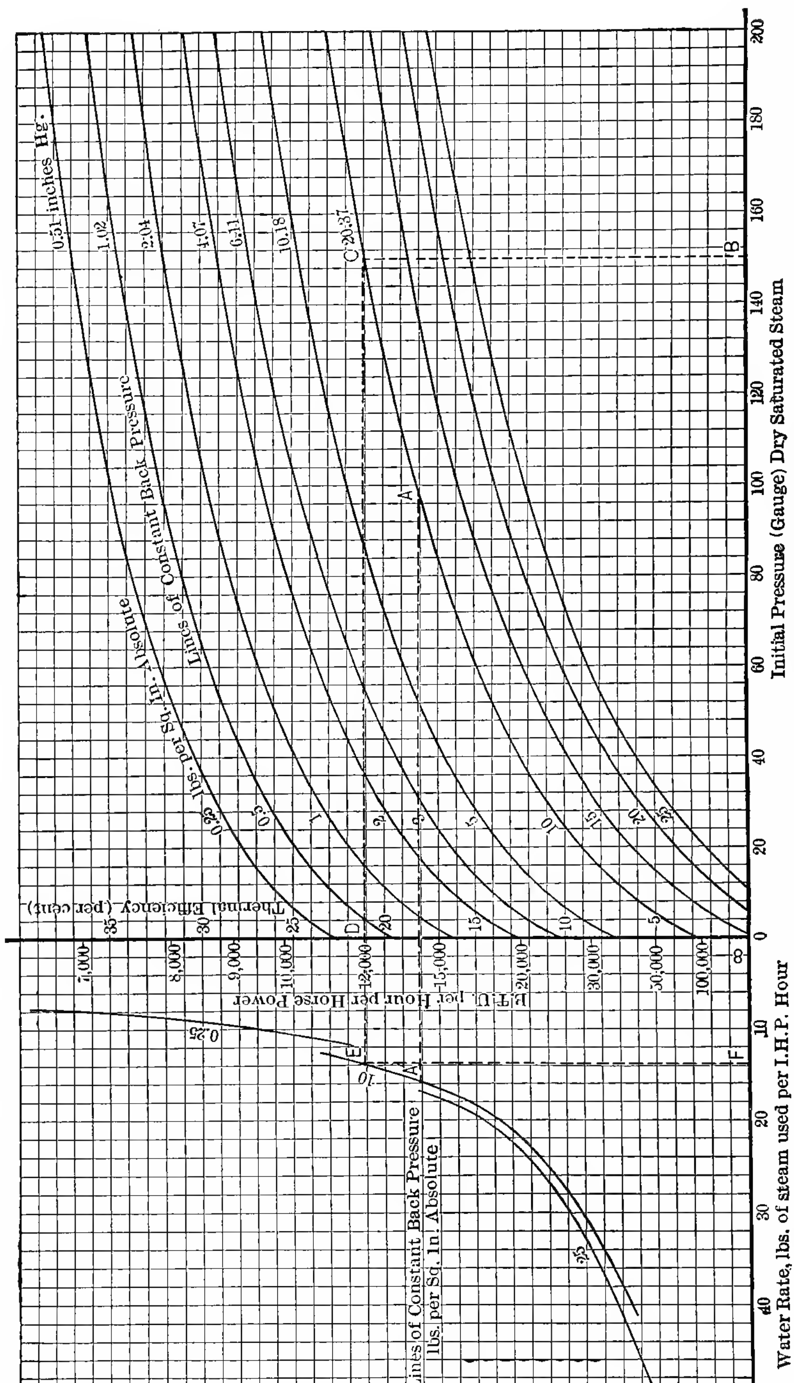


CHART 50.—Carnot Steam Cycle and Derivatives. Thermal Efficiency, Heat per Hour per Horse-power and Water Rate for Various Back Pressures, and any Initial Pressure, Steam Initially Dry Saturated.

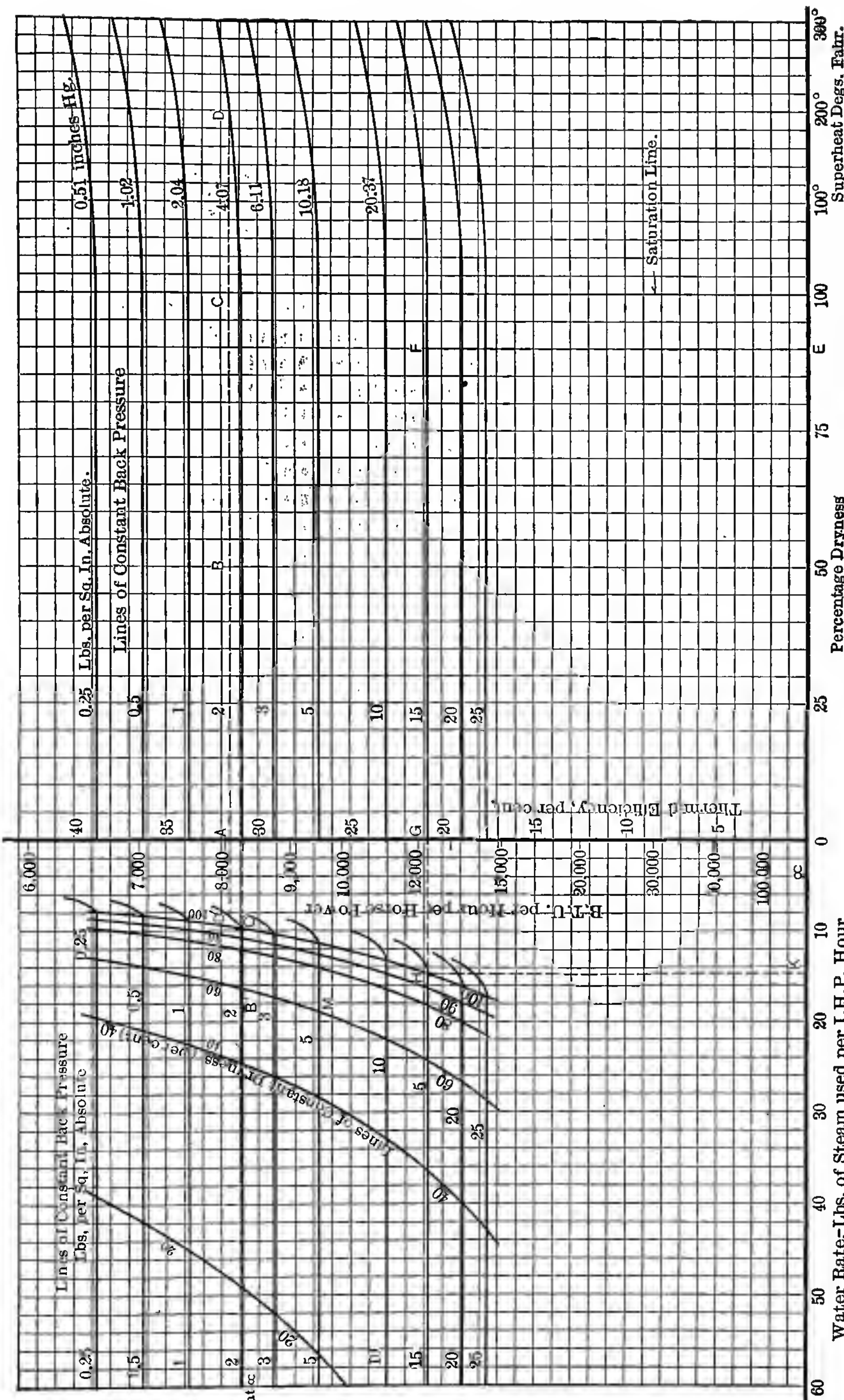


CHART 51.—Carnot Steam Cycle and Derivatives. Thermal Efficiency, B.T.U. per Hour per Horse-power and Water Rate, for 200 lbs. per sq. in. gage Initial and Various Back Pressures, Steam Initially of any Quality.

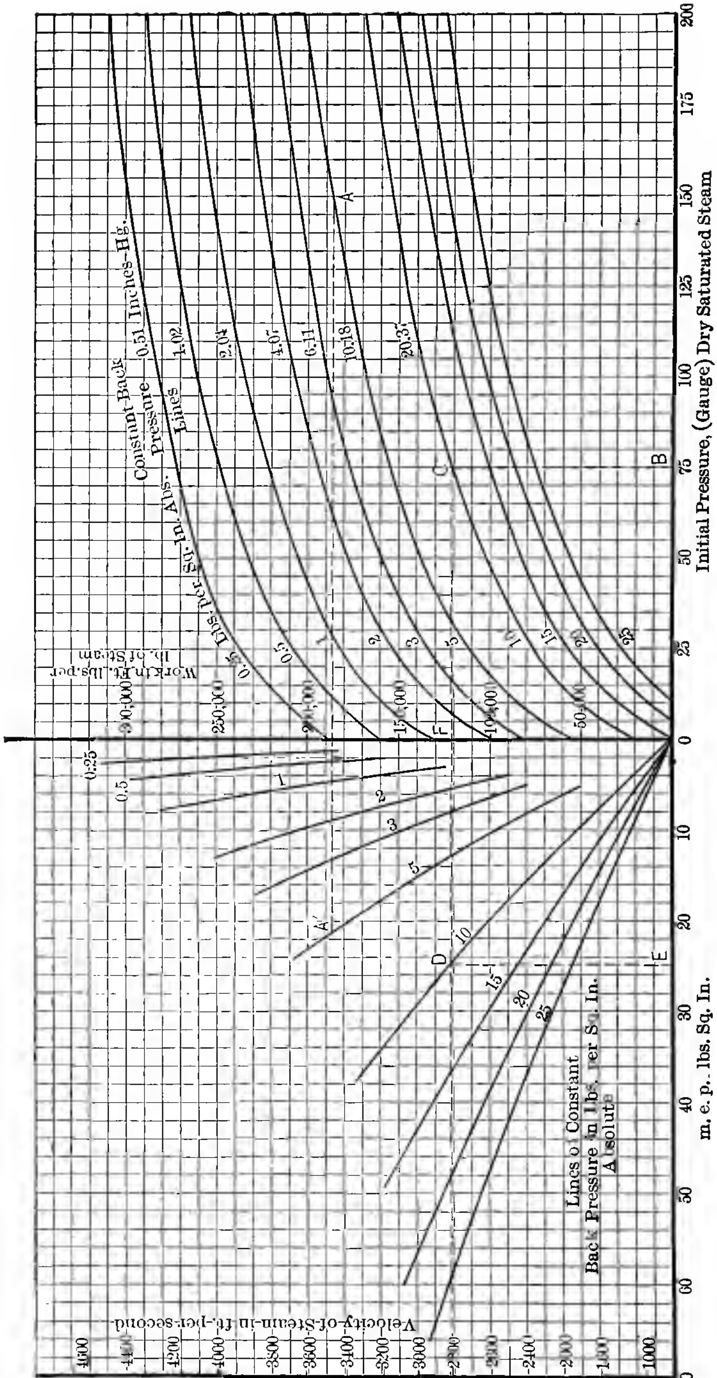


CHART 52.—Carnot Steam Cycle and Derivatives. Work per lb. of Steam, (m.e.p.) and Jet Velocity for Various Back Pressures and any Initial pressure, Steam Initially Dry and Saturated.

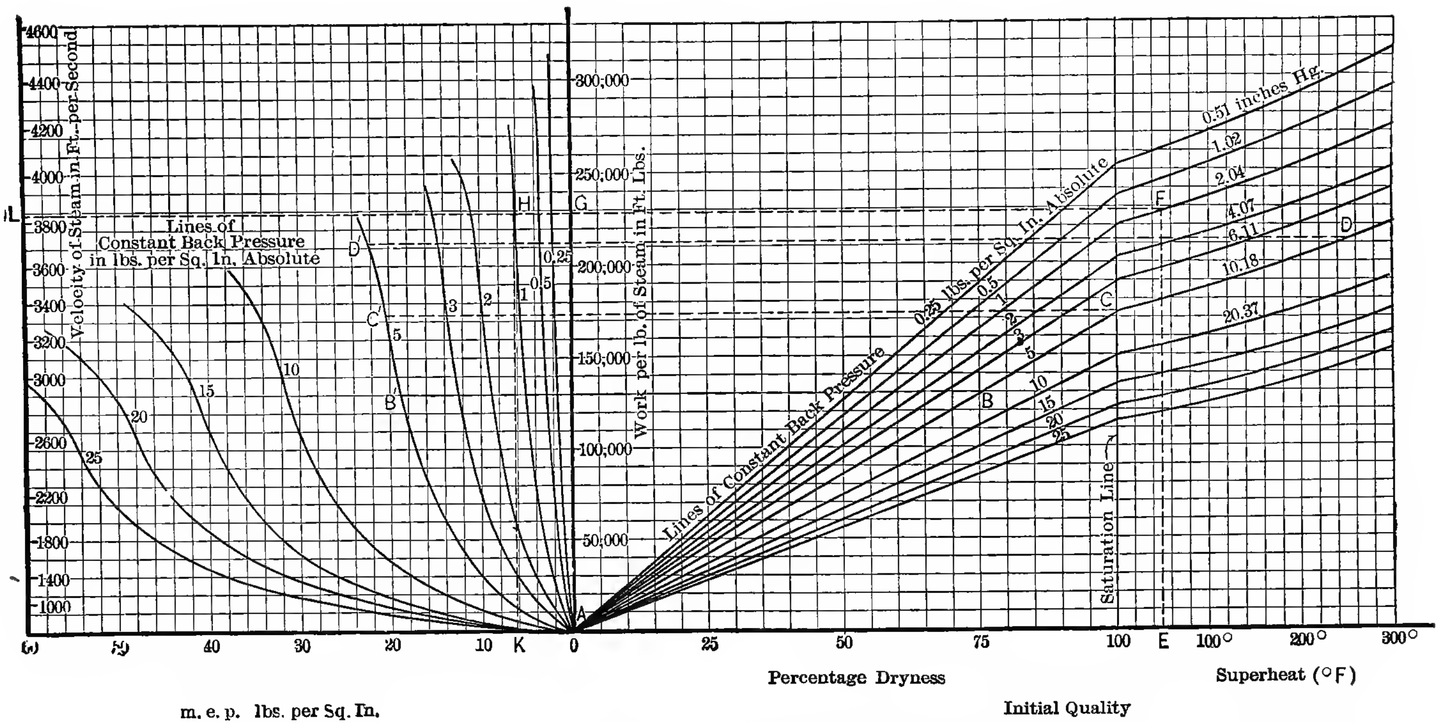


CHART 53.—Carnot Steam Cycle and Derivatives. Work per lb. of Steam, (m.e.p.) and Jet Velocity, for 200 lbs. per sq.in. gage Initial and Various Back Pressures, Steam Initially of any Quality.

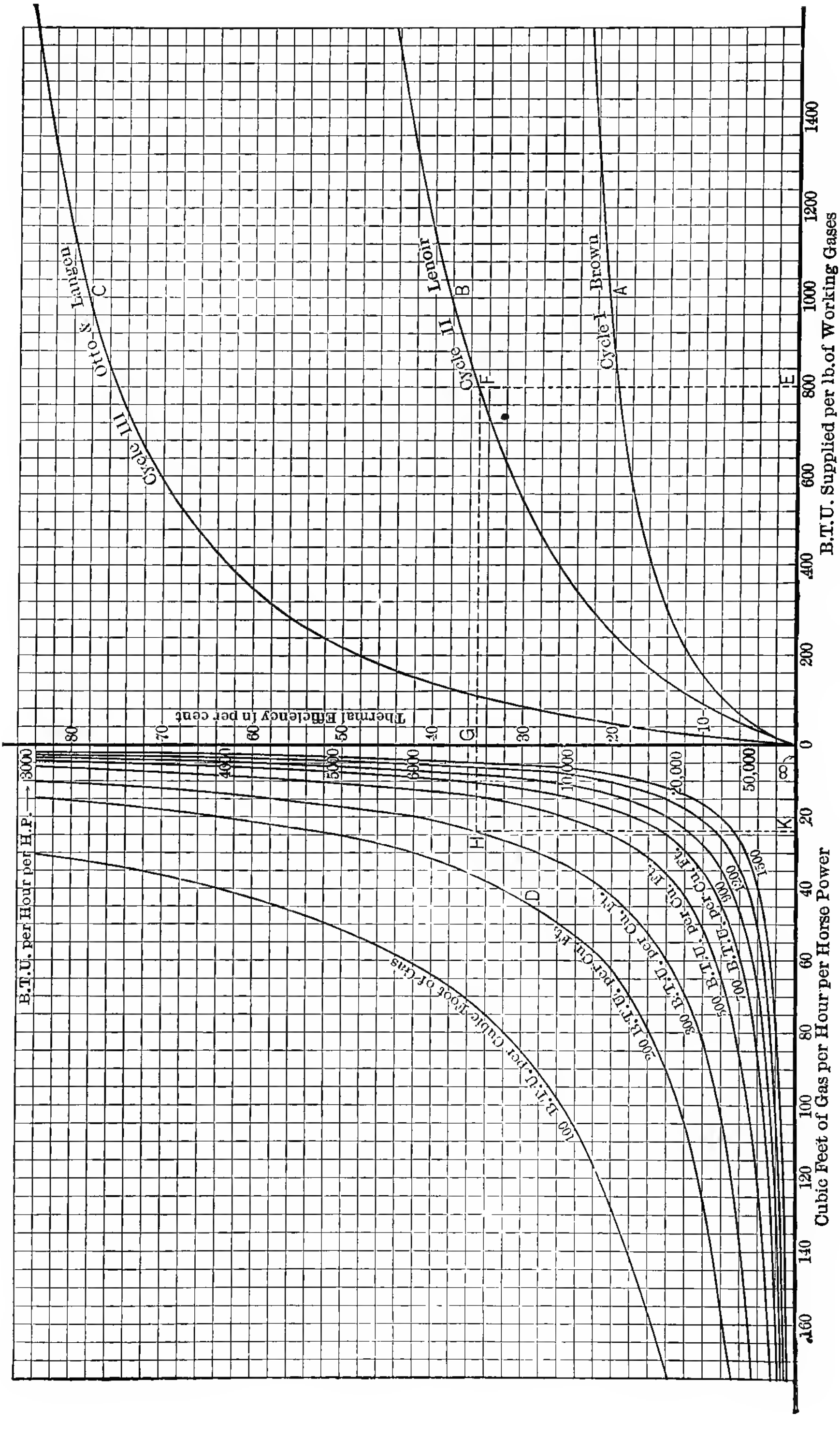


CHART 54.—Thermal Efficiency, Heat and Gas Consumption for any amount of Heat Supplied per lb. of Working Gases, for the Non-compression Gas Cycles, Brown, Lenoir, and Otto and Langen.

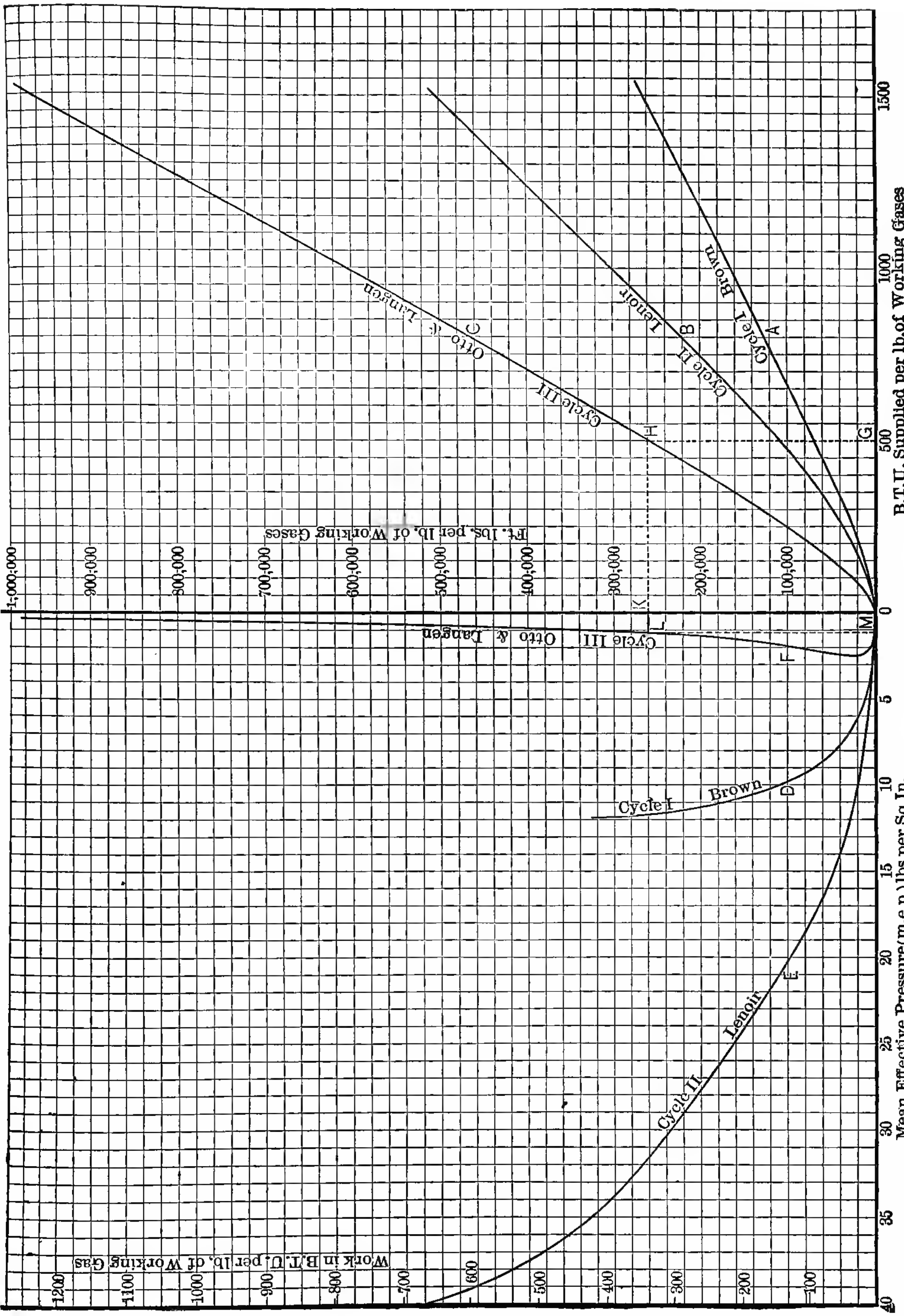


CHART 55.—Work per lb. of Gases and (m.e.p.), for any amount of Heat Supplied per lb. of working Gases, for the Non-compression Gas Cycles, Brown, Lenoir, and Otto and Langen.

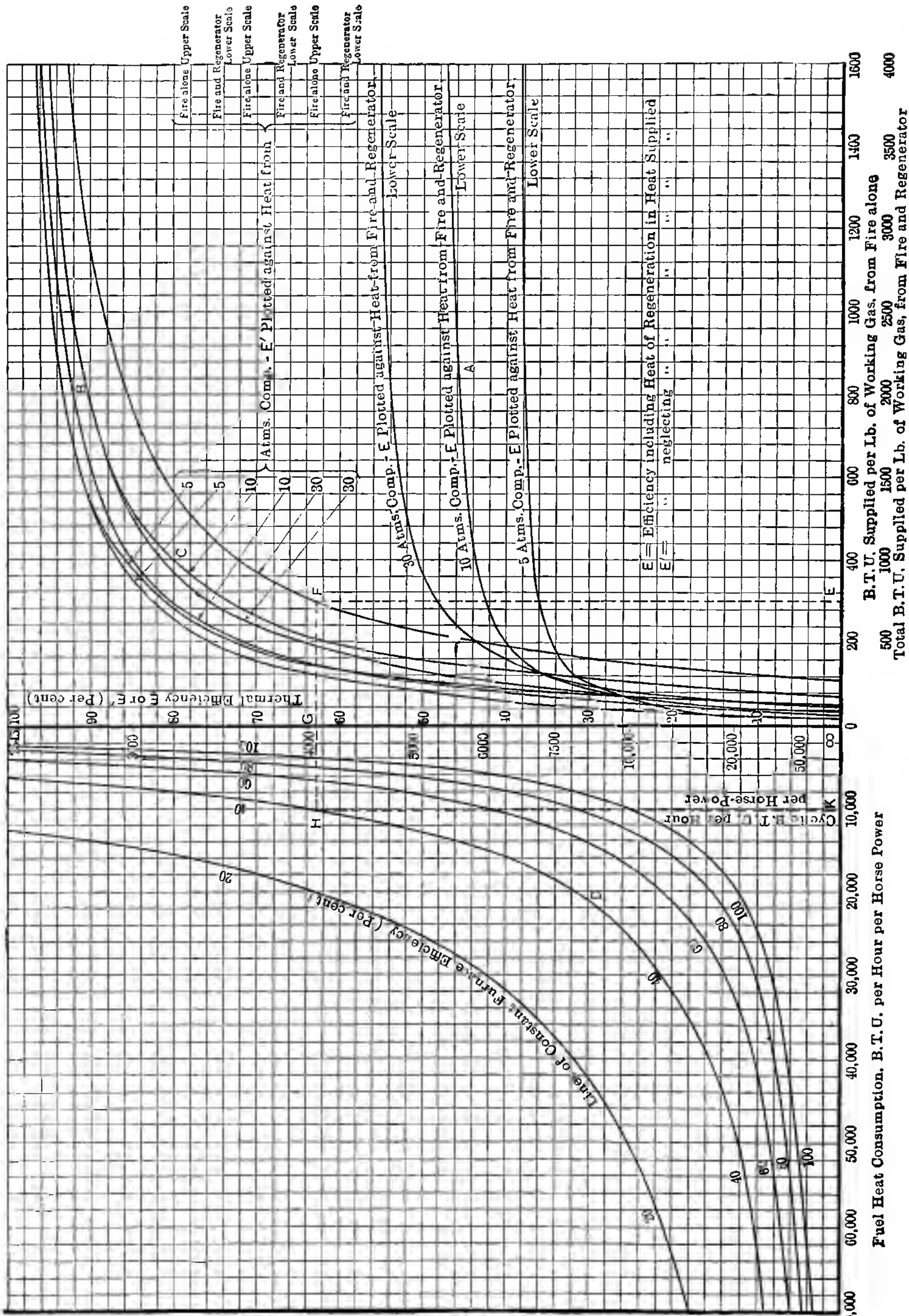


Chart 56.—Stirling Gas Cycle. Thermal Efficiency, Considering or Neglecting Heat of Regeneration, Plotted against *Heat* from Fire or Total Heat Supplied per lb. Working Gases, Cyclic B.T.U. per Hour per Horse-power and fuel Consumption for Various Furnace Efficiencies.

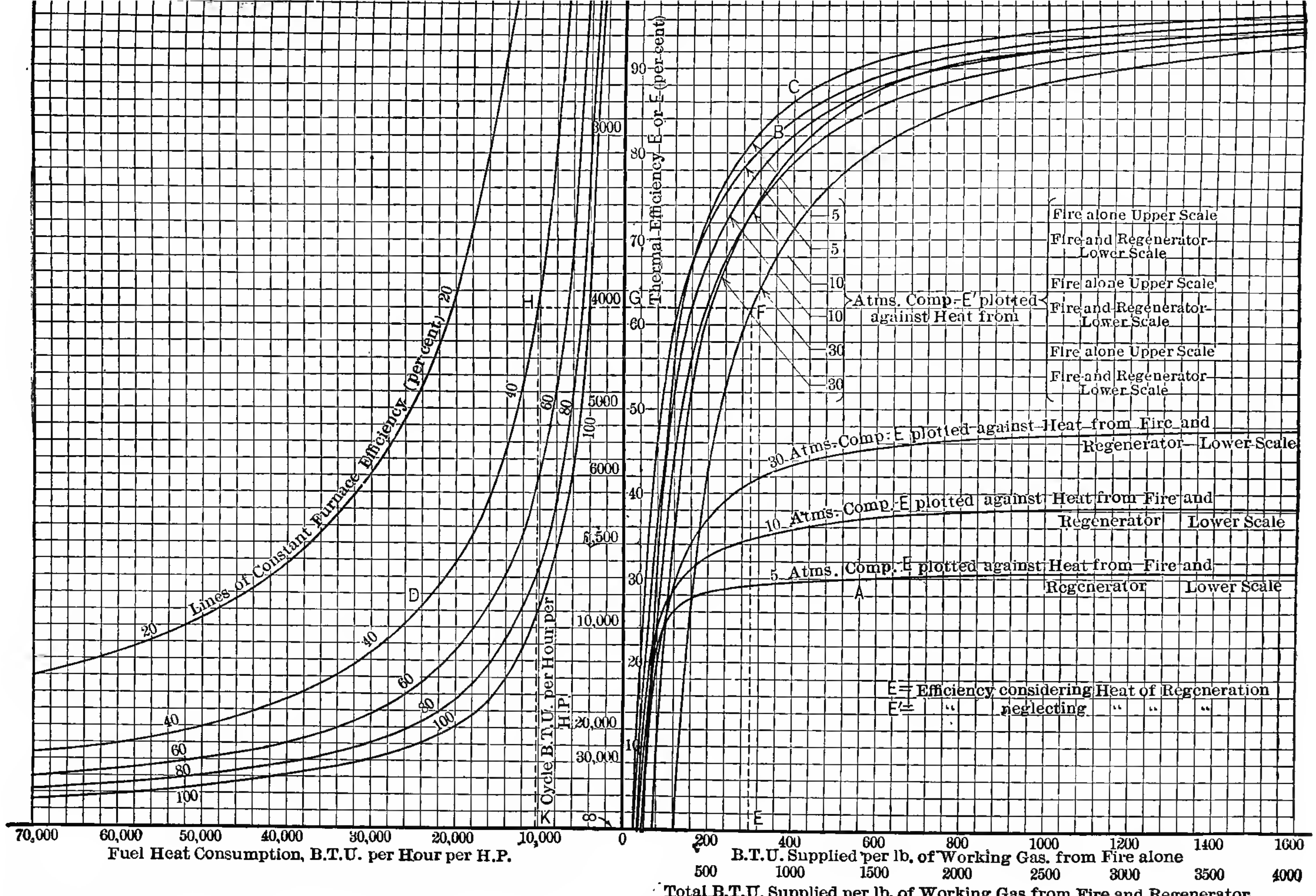
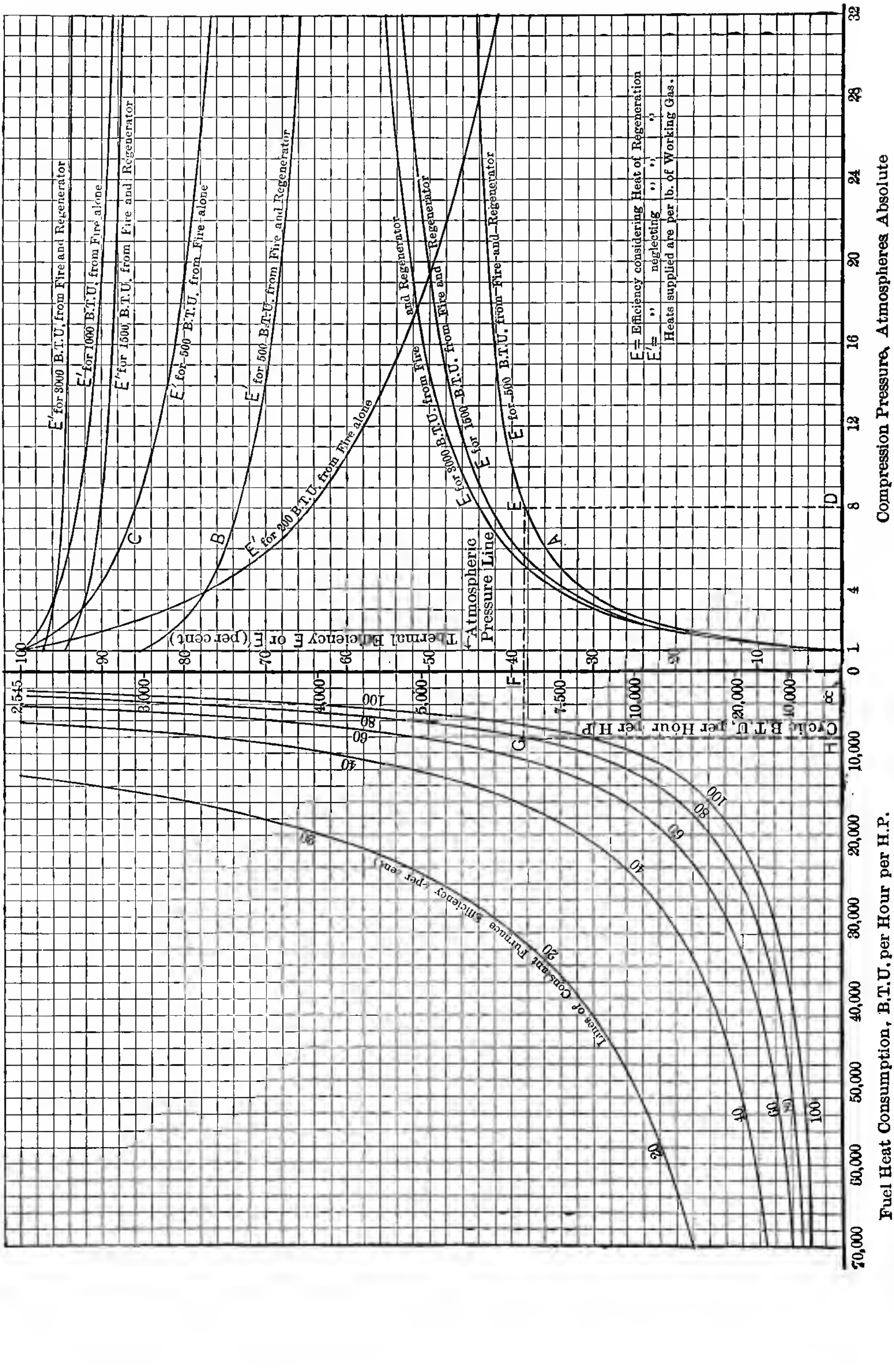


Chart 57.—Ericsson Gas Cycle. Thermal Efficiency, Considering or Neglecting Heat of Regeneration Plotted against *Heat* from the Fire or Total Heat Supplied per lb. of Working Gases, Cyclic B.T.U. per Hour per Horse-power and Fuel Heat Consumption for Various Furnace Efficiencies.



E′ for 3000 B.T.U. from Fire and Regenerator
E′ for 1000 B.T.U. from Fire alone
E′ for 1500 B.T.U. from Fire and Regenerator
E′ for 500 B.T.U. from Fire alone
E′ for 500 B.T.U. from Fire and Regenerator
E′ for 200 B.T.U. from Fire alone
E for 3000 B.T.U. from Fire and Regenerator
E for 1500 B.T.U. from Fire and Regenerator
E for 500 B.T.U. from Fire and Regenerator
E = Efficiency considering Heat of Regeneration
E′ = " neglecting " "
Heats supplied are per lb. of Working Gas.
Atmospheric Pressure Line
Thermal Efficiency E or E′ (per cent)
Cycle B.T.U. per Hour per H.P.
Lines of Constant Furnace Efficiency (per cent)
Compression Pressure, Atmospheres Absolute
Fuel Heat Consumption, B.T.U. per Hour per H.P.

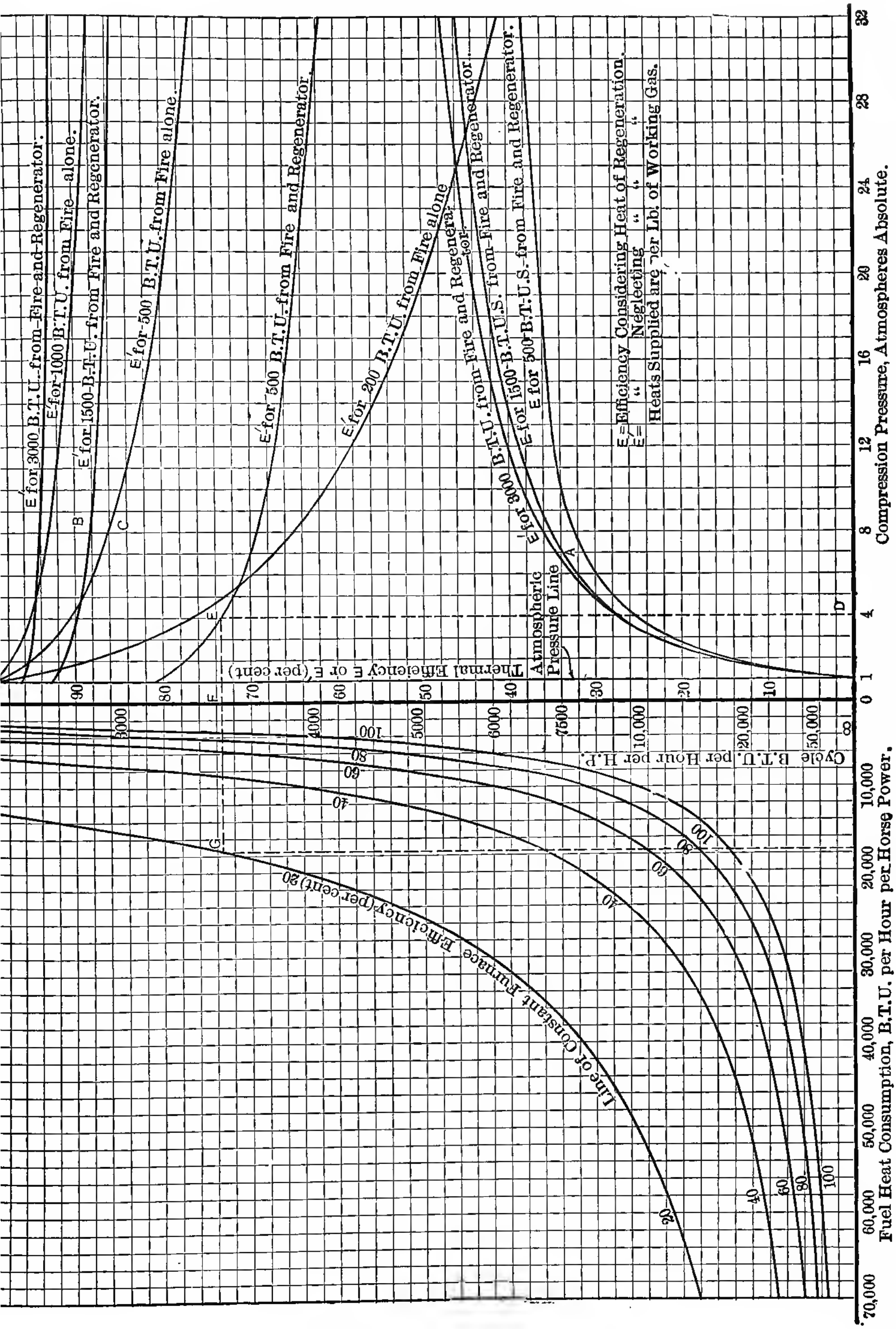


CHART 59.—Ericsson Gas Cycle. Thermal Efficiency, Considering or Neglecting Heat of Regeneration Plotted against *Compression* Pressure. Cyclic B.T.U. per Hour per Horse-power and Fuel Heat Consumption for Various Furnace Efficiencies.

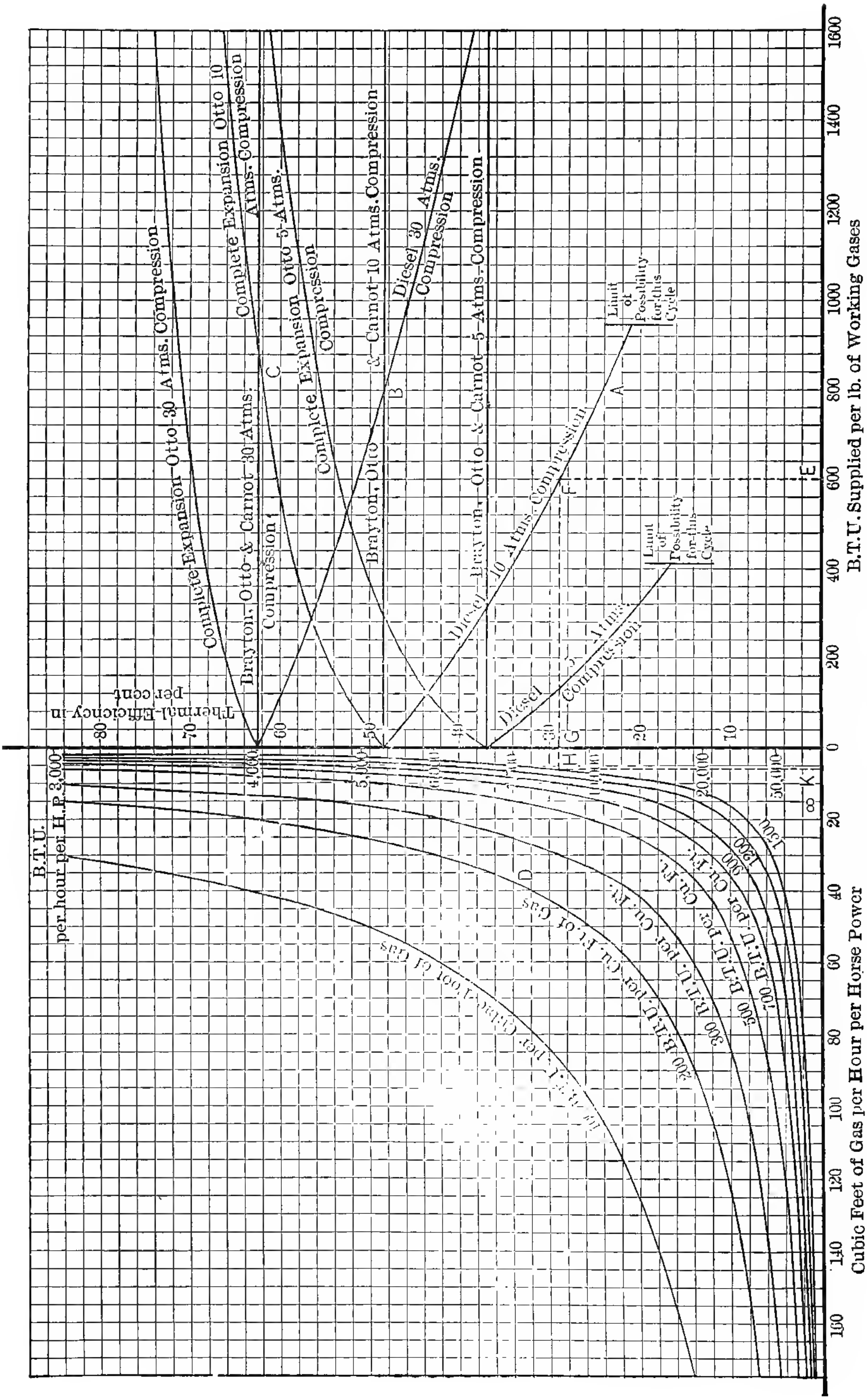


CHART 60.—Otto, Brayton, Carnot, Diesel, and Complete Expansion Otto Cycles. Thermal Efficiency, Heat, and Gas Consumption, with *Heat Supplied* per lb. of Working Gases, for the Compression Gas Cycles.

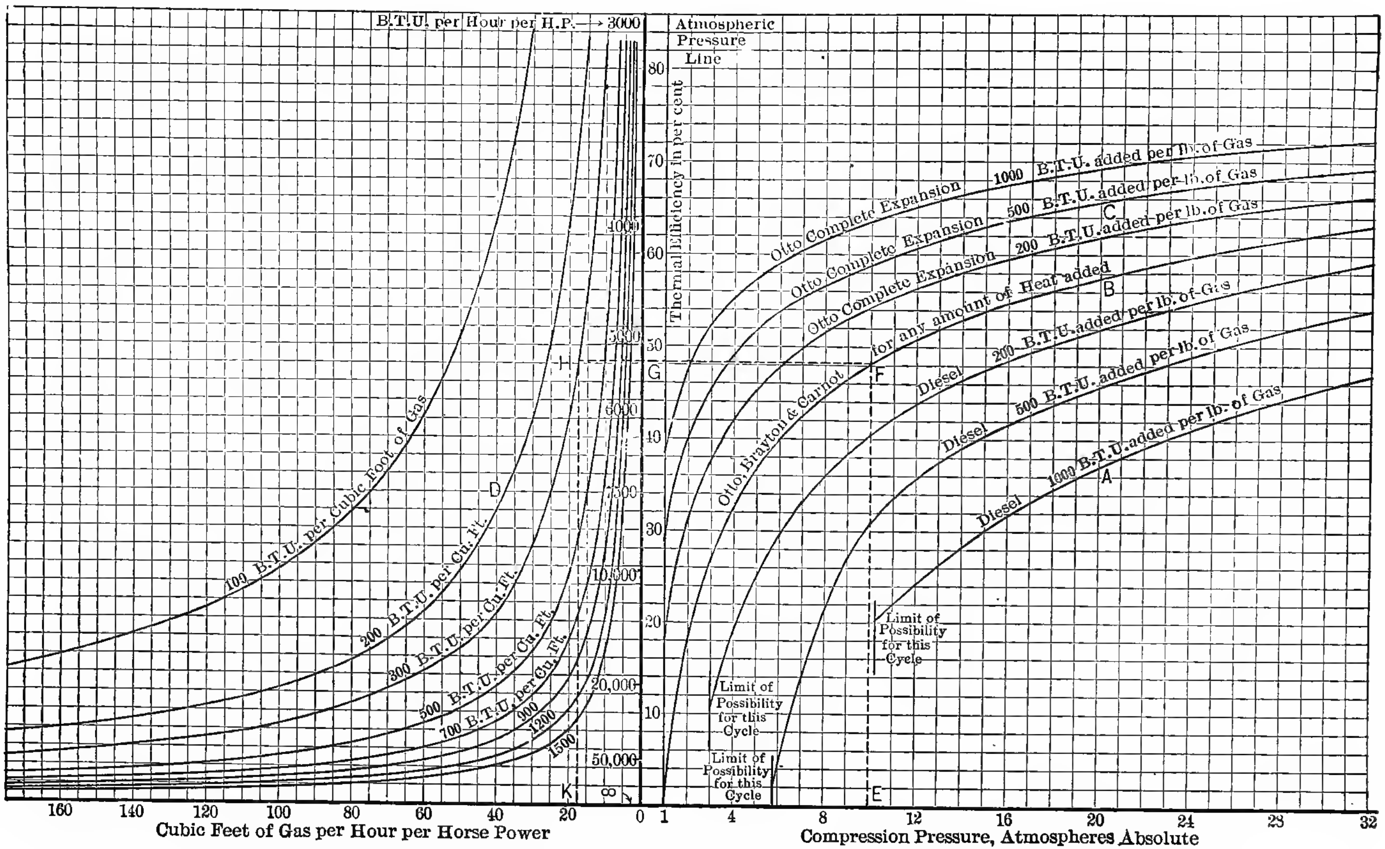


CHART 61.—Otto, Brayton, Carnot, Diesel, and Complete Expansion Otto Cycles. Thermal Efficiency, Heat, and Gas Consumption, with *Compression*, for the Compression Gas Cycles

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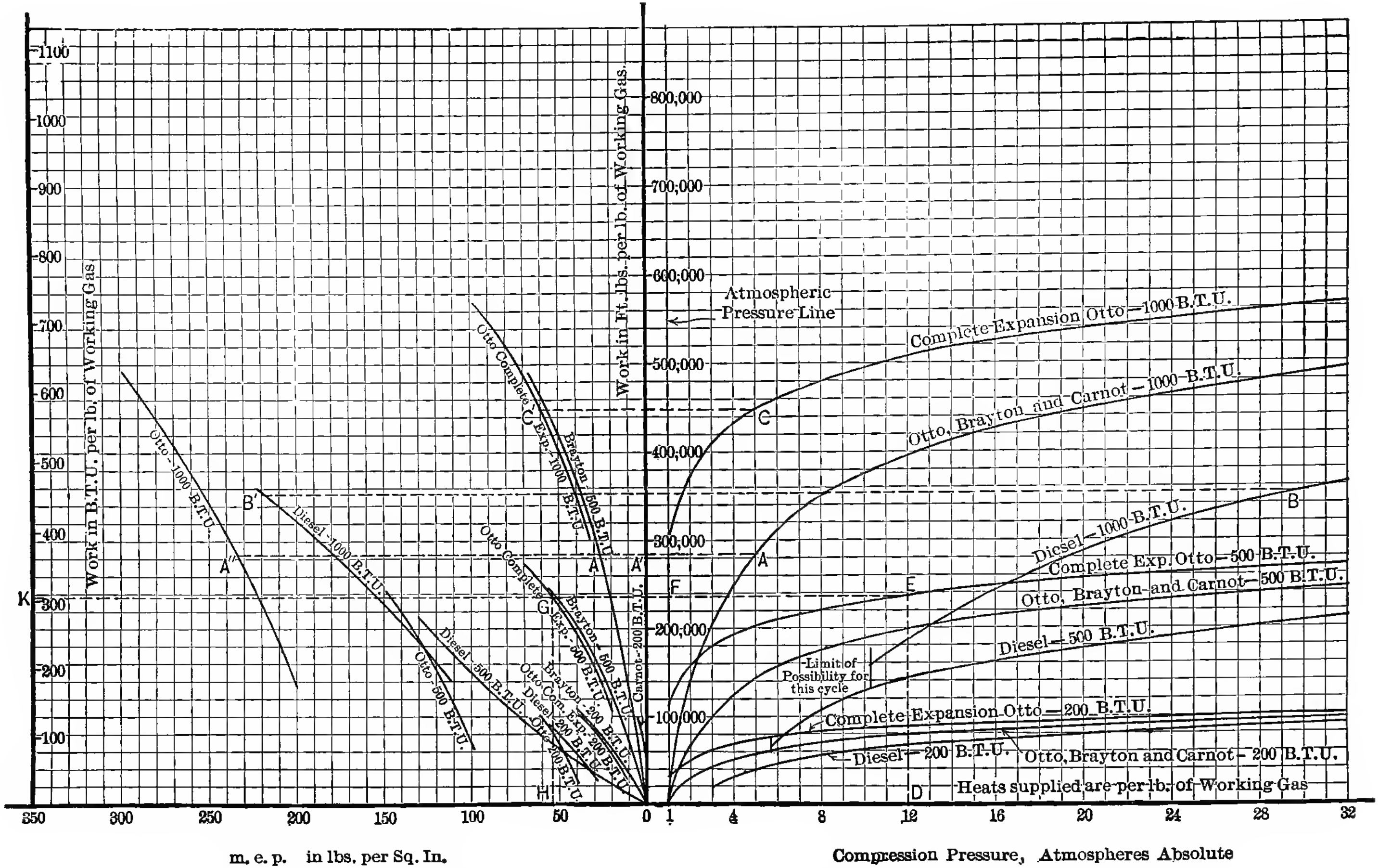


CHART 63.—Otto, Brayton, Carnot, Diesel, and Complete Expansion Otto Cycles. Work per lb. of Working Gases and (m.e.p.) with *Compression*, for the Compression Gas Cycles.

CHART 64.—Otto Gas Cycle. Work per lb. of Working Gases and (m.e.p.) for Various Amounts of Heat Added after any Amount of Compression.

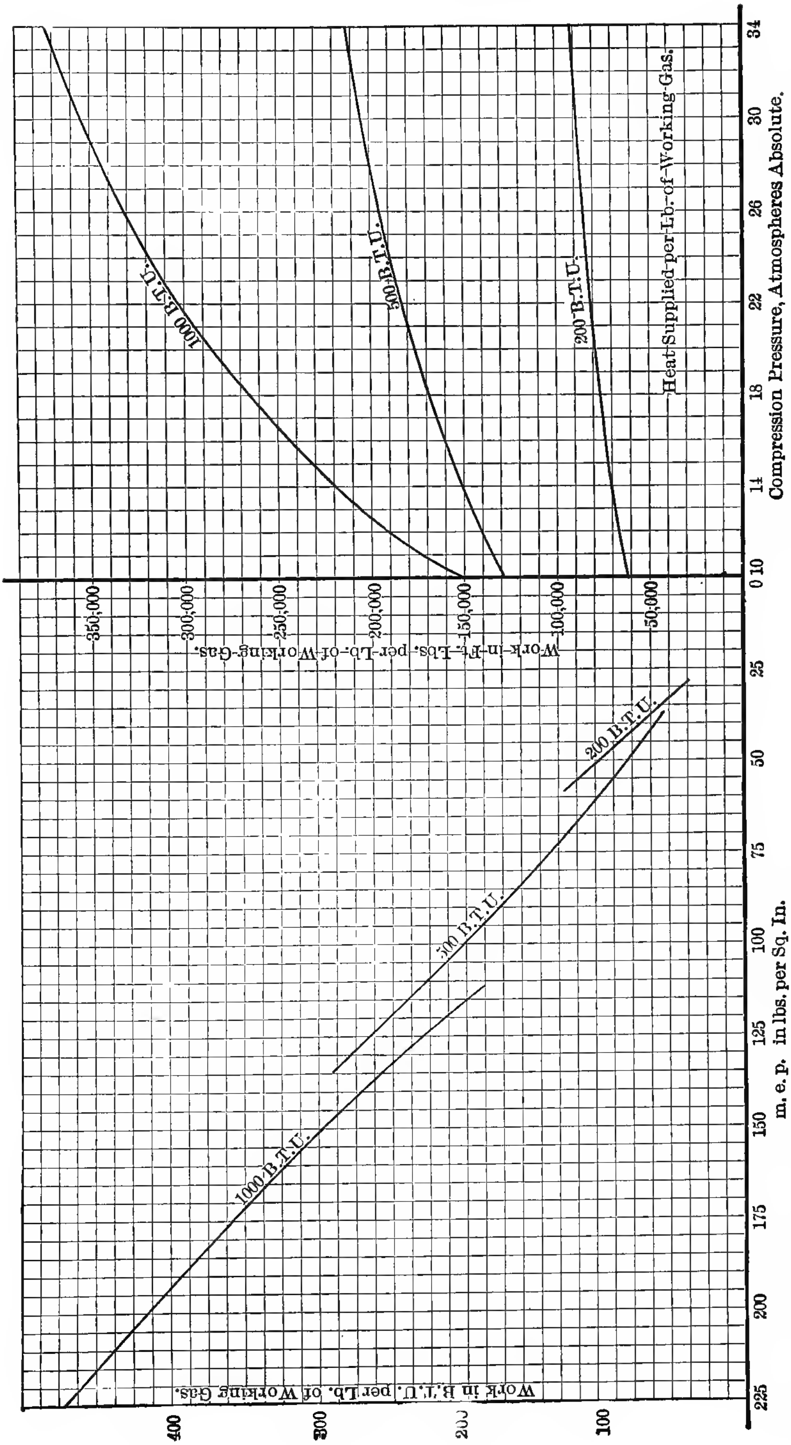


CHART 65. Diesel Gas Cycle.—Work per lb. of Working Gases and (m.e.p.) for Various Amounts of Heat Added after any Amount of Compression.

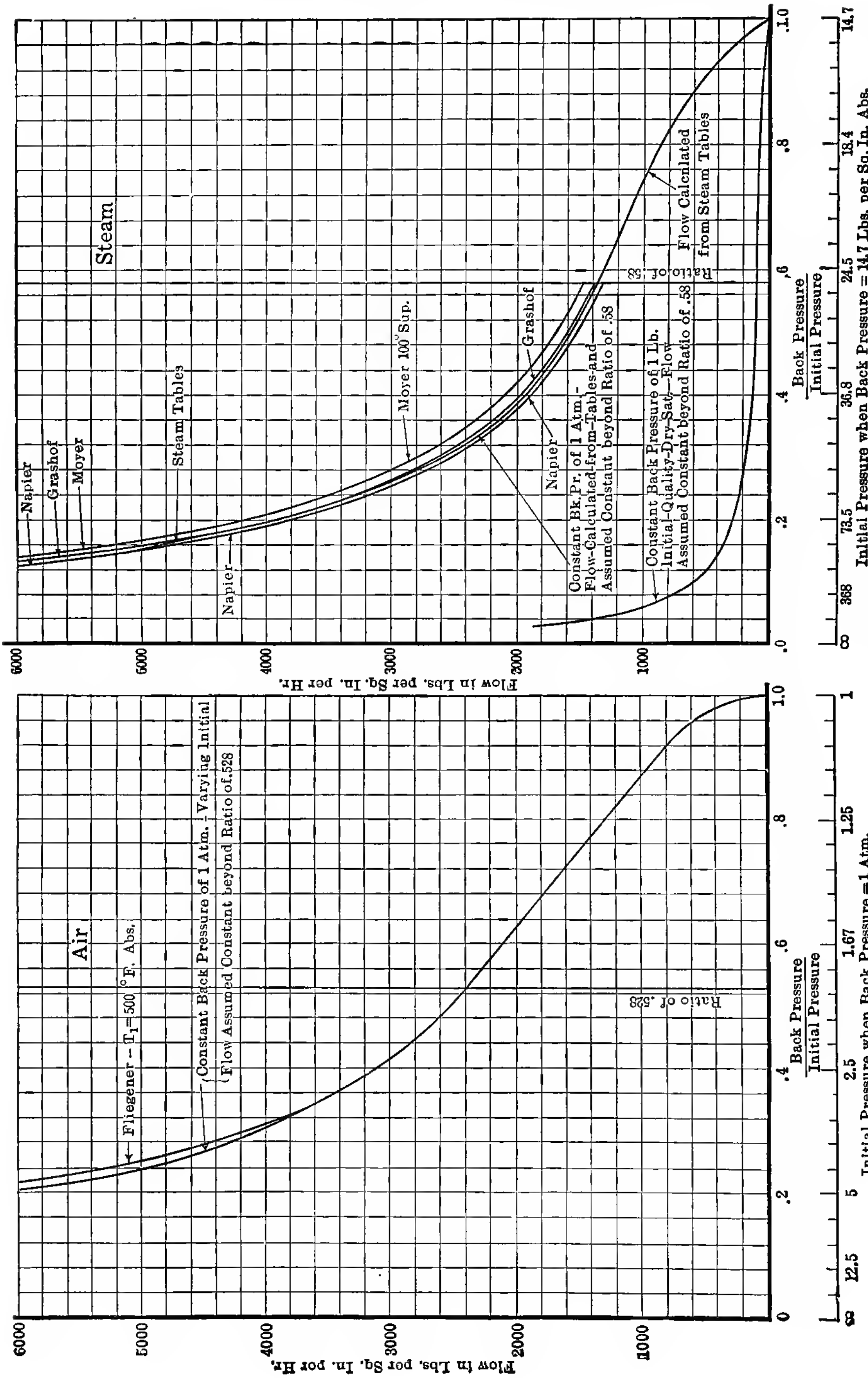


CHART 66.—Comparison of Rational and Empiric Formulas for Air and Steam Flow with Large Pressure Drops. *Constant Back*, and any Initial Pressure.

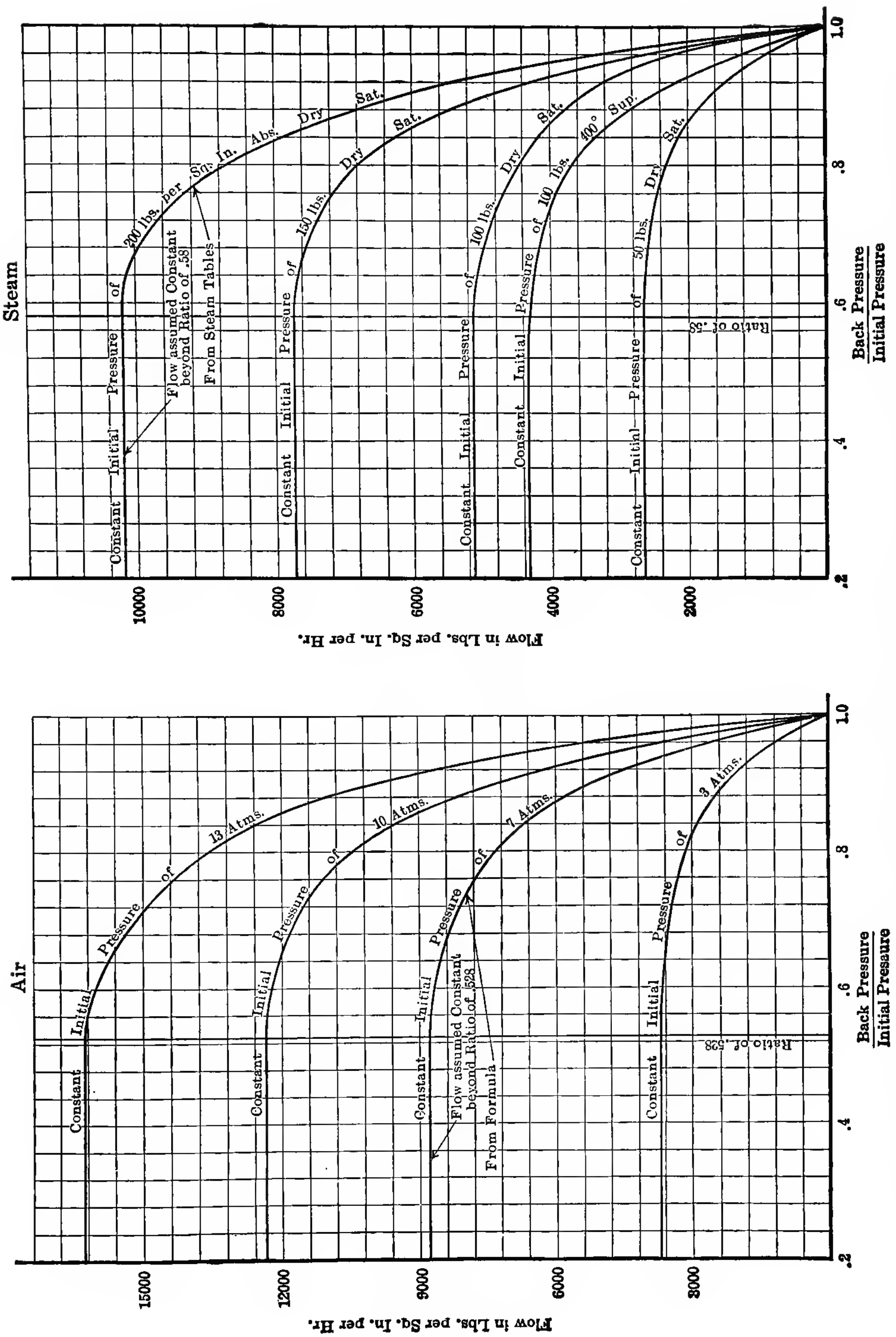


CHART 67.—Comparison of Rational and Empiric Formulas for Air and Steam Flow with Large Pressure Drops. *Constant Initial* and any Back Pressure.

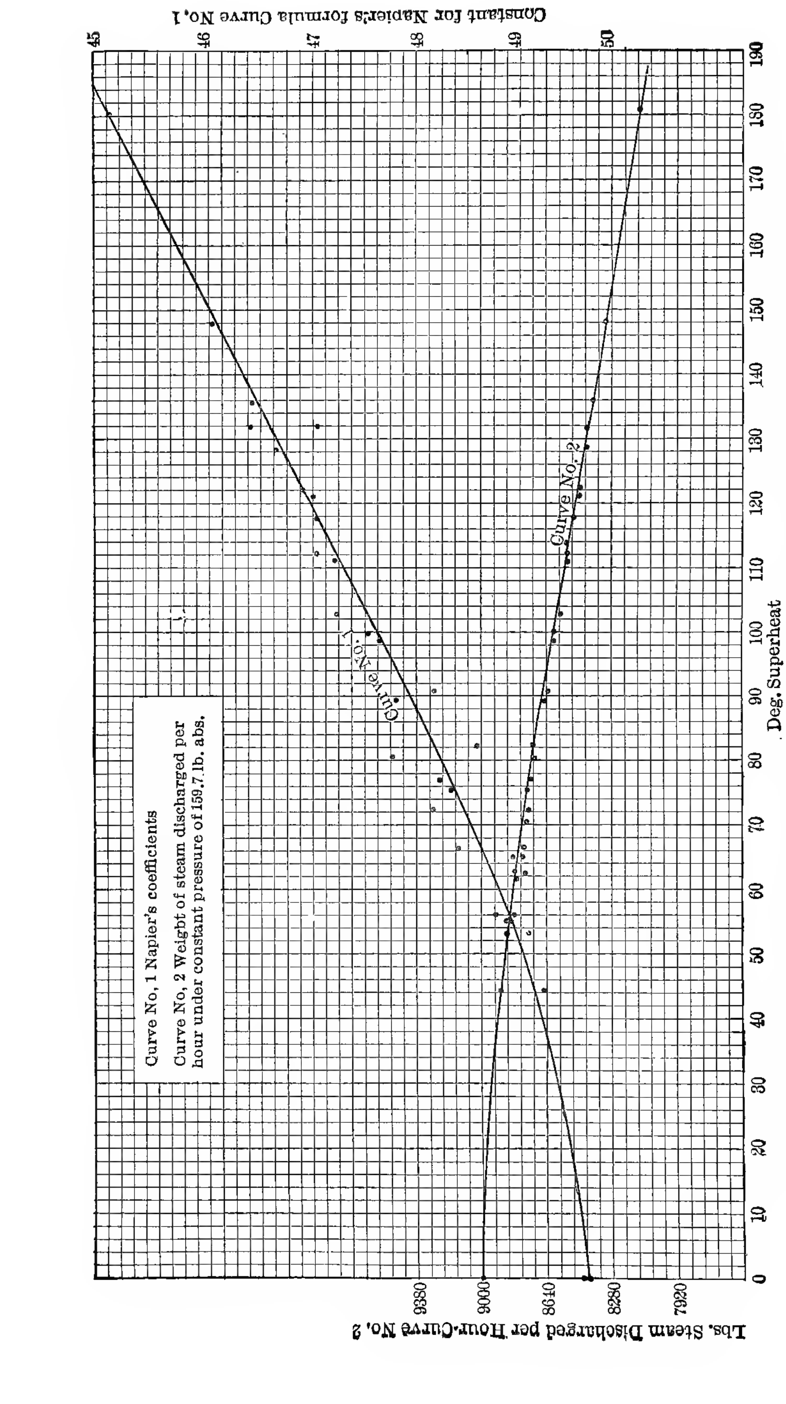


CHART 68.—Harter's Values of Napier's Coefficient and Weight of Flow for Superheated Steam.

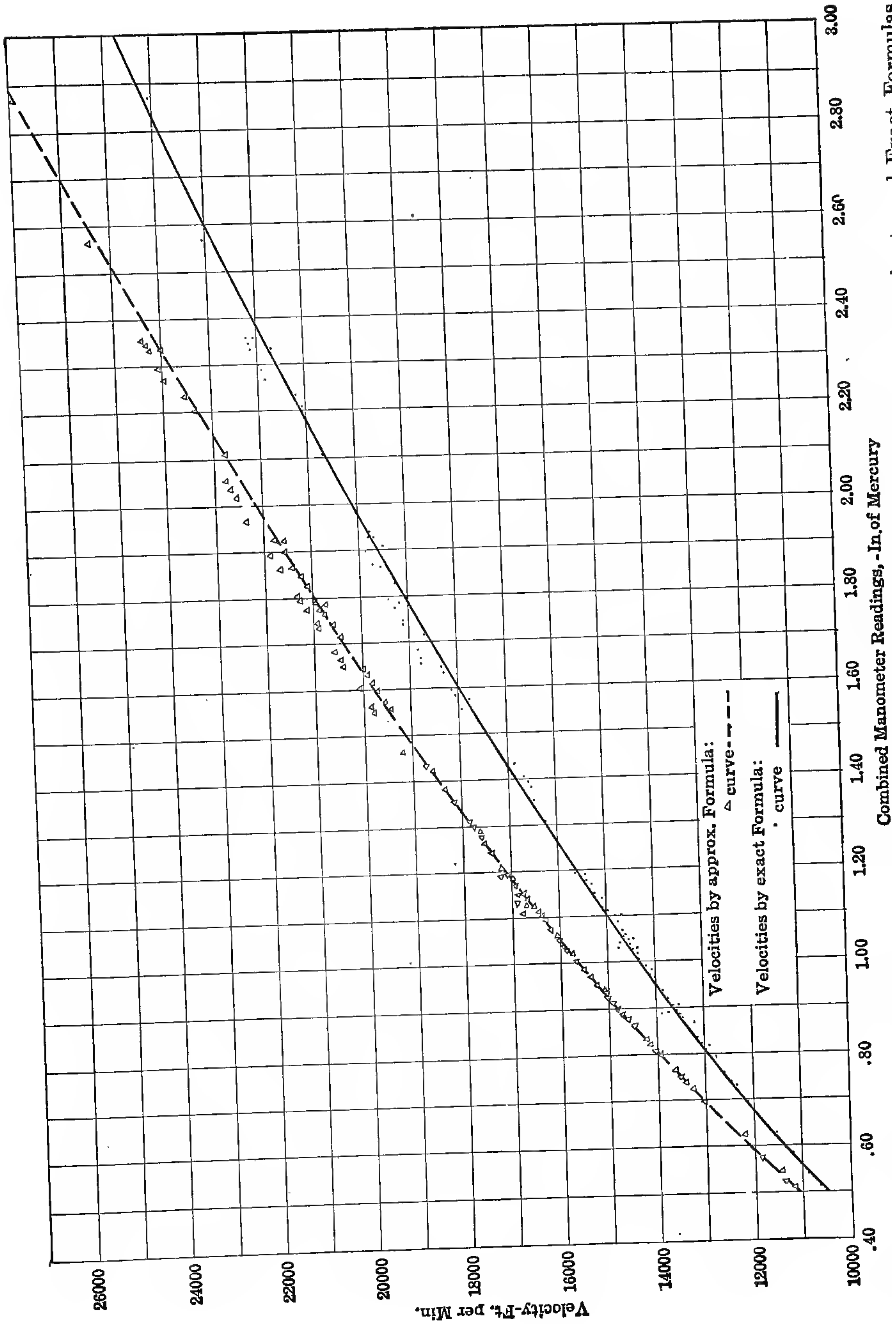


CHART 69.—Velocity of Air in Pipes in Terms of Pitot Tube Readings, Inches of Mercury, by Approximate and Exact Formulas.

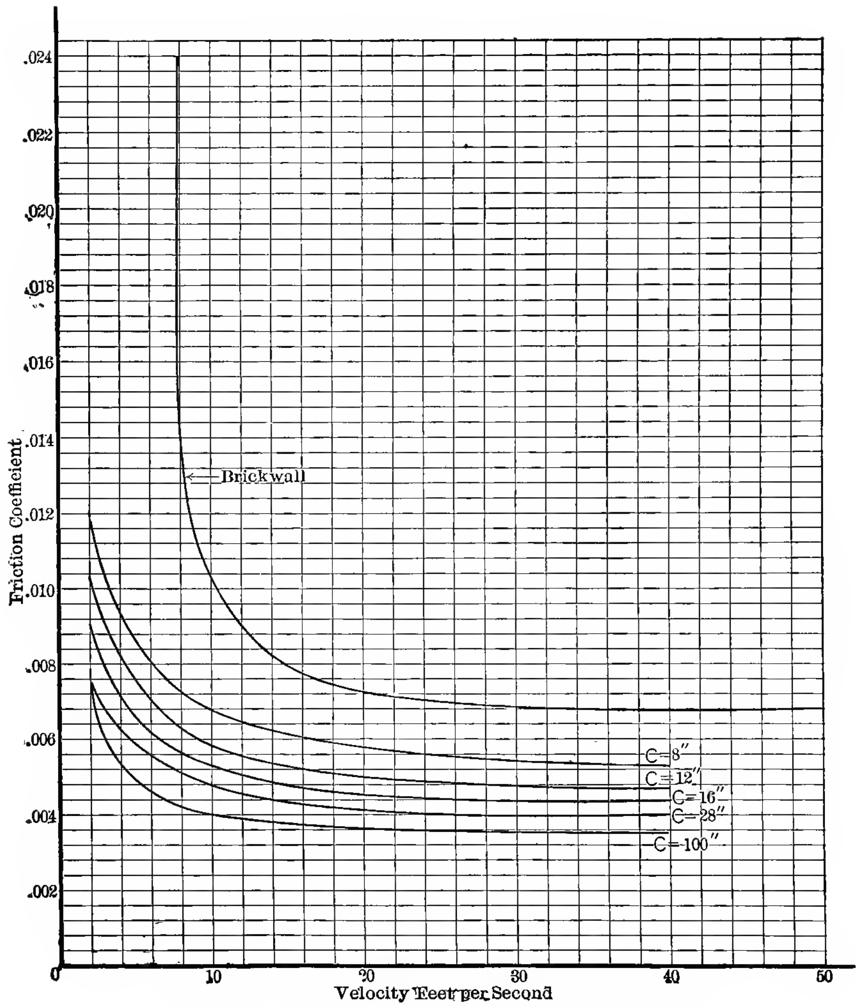


CHART 70.—Coefficients of Friction ζ for Air in Ducts.

These values of the coefficient of friction are given by Rietschel for straight ducts of brick and iron for velocities up to 50 ft. per second; for iron ducts different values are given for perimeters or circumferences from 8 to 100 in. They are intended especially for air ducts with the usual velocities of air, 6 to 24 ft. per second when served by fans, and 3 to 8 ft. per second when the flow is due to natural draft.

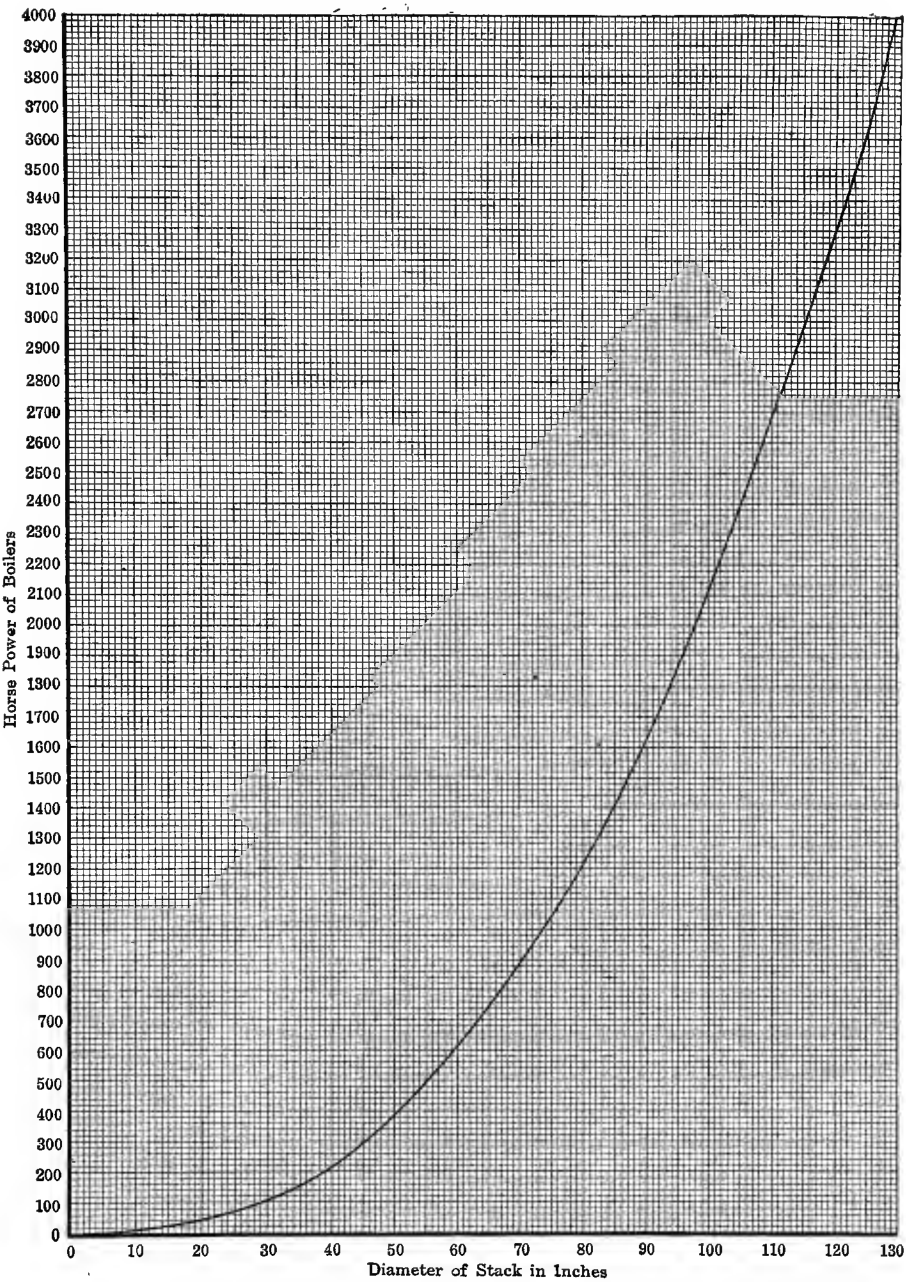


CHART 71.—Curve Showing Diameter of Chimney Stacks at Sea Level. (Stirling). For brick or brick-lined stacks, increase the diameter 6 per cent.

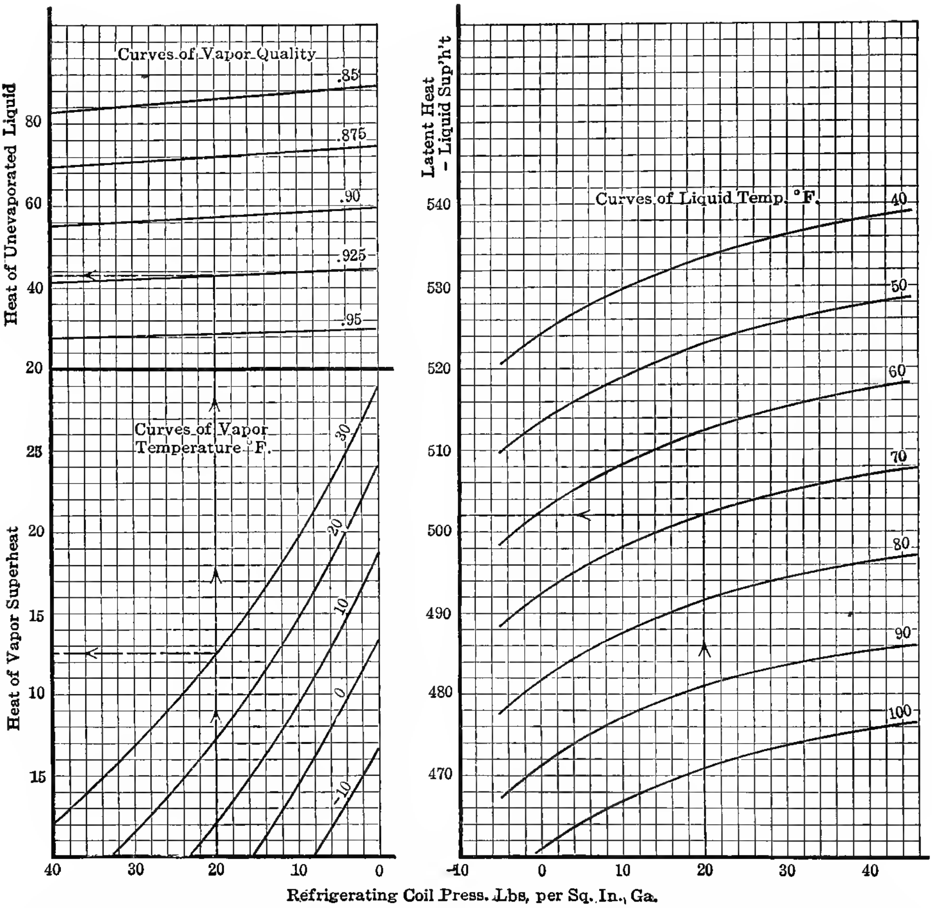


CHART 72.—Chart to Determine Available Refrigerating Effect per Pound of *Ammonia* for Any Refrigerator Pressure and Any Refrigerator or Liquid Temperature.

Construction and use of Diagrams, Charts 72 and 73. These diagrams are for the purpose of finding the refrigerating effect per pound of fluid, which is made up of the latent heat, or as much of it as is available, less the heat necessary to cool the liquid from its original temperature to that due to the pressure in the coils, plus the heat absorbed in superheating the vapor.

A horizontal scale of pressures is laid off in both directions for a vertical axis carrying a B.T.U. scale. In the section to the right of the center axis curves are drawn representing various temperatures of the liquid before entering the refrigerator coils. These are so drawn that the vertical scale opposite the intersection of a vertical from any pressure with any curve gives the latent heat for that pressure, less the heat required to cool the liquid. This is the available heat for refrigerating if the vapor leaves the coils dry and saturated.

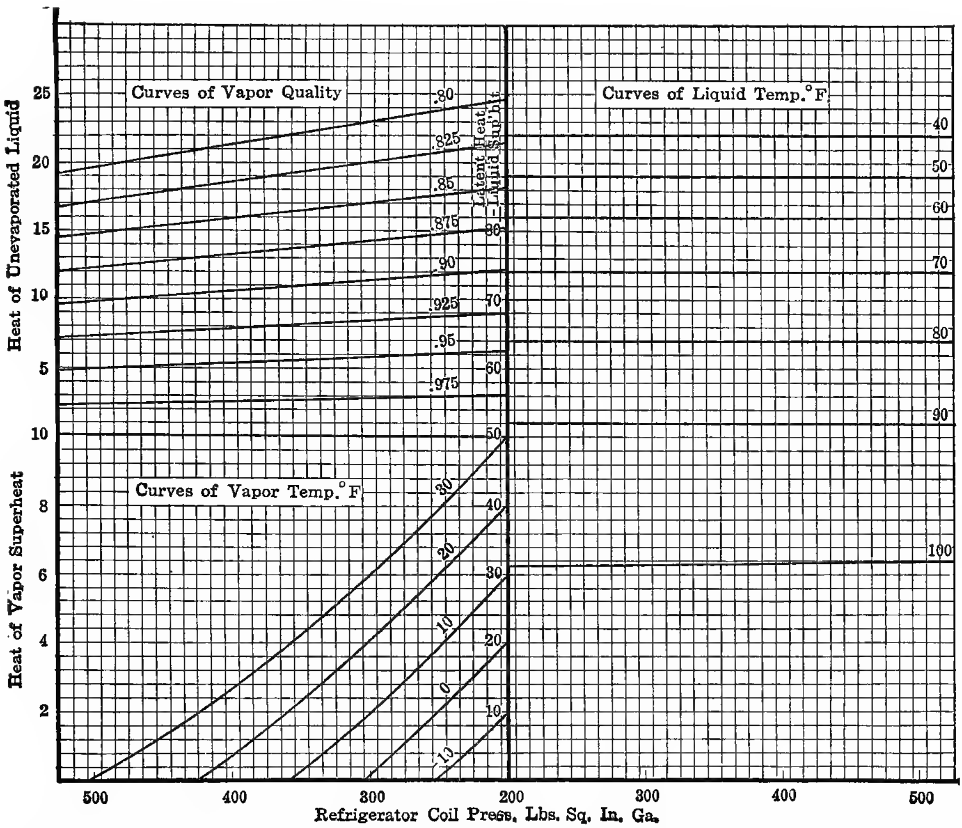


CHART 73.—Chart to Determine Available Refrigerating Effect per Pound of *Carbon Dioxide* for any Refrigerator Pressure and any Refrigerator or Liquid Temperature.

In the section to the left of the center axis are two sets of curves, the lower, representing temperatures of the vapor leaving the coils, is so drawn that the value of the left-hand vertical scale opposite a point of intersection of a vertical from any pressure with any curve, gives the heat absorbed in superheating the vapor. The sum of this and the value found in the first section gives the total refrigerating effect for the case when the vapor leaves the coils in a superheated state. The upper curves in this section represent quality of the vapor if the liquid has not been entirely evaporated and are so drawn that the value on the vertical scale opposite the point of intersection of a vertical from any pressure with any curve, shows the heat unavailable for refrigerating, due to incomplete evaporation of the liquid, and the difference between this value and that found in the first section gives the total refrigerating effect for the case of wet vapor leaving the coils.

As an example of the use of Chart 72 let it be required to find the refrigerating effect per pound of ammonia when the pressure in the coils is 20 lbs. gage, the temperature of the liquid

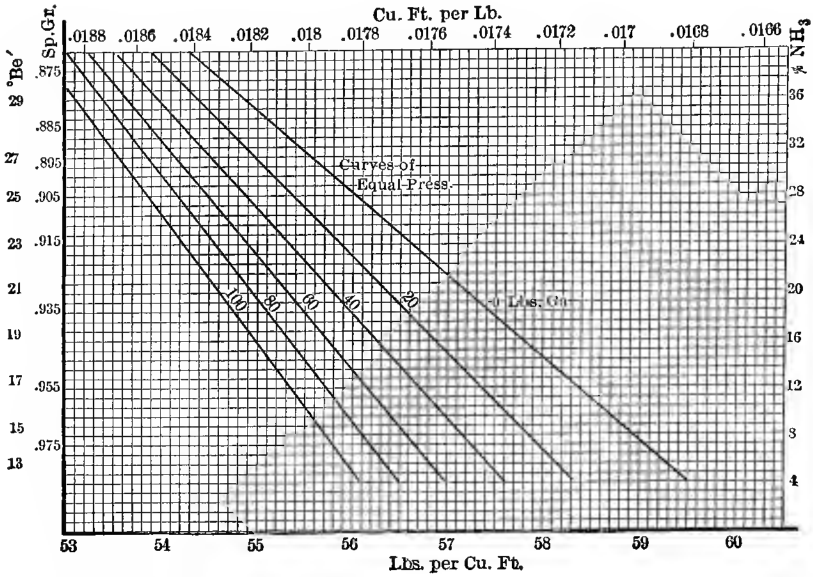


CHART 74.—Density and Specific Volume of Ammonia-water Solutions.

before entering the coil is 70° F. and

(a) Vapor leaves dry and saturated;
(b) Vapor leaves 92.5 per cent. dry;
(c) Vapor leaves at a temperature of 30° F.

From 20 in the right-hand section (Chart 72) project up to curve 70° The value on the vertical scale at this point is 502 B.T.U., which is the value for case (a). From 20 in the left-hand section project to curve 92.5 per cent.; the value on the left-hand vertical scale is 43, therefore, for case (b) the result is 502 − 43 = 459 B.T.U. For case (c), project from 20 to curve 30°, the value on the vertical scale corresponding to which is 12.5, hence the result for this case is 502 + 12.5 = 514.5.

The refrigeration per pound of fluid may be obtained from Eq. (1030), but since these are all tabular values, except the heat of air and of vapor superheat, the determinations can be readily made by means of the charts. From the data of these diagrams the displacements of compressors and pumps may be computed directly by the use of the slide-rule. When superheated vapor densities are to be evaluated, either vapor—ammonia or carbon dioxide—may be assumed to behave as a perfect gas, volumes being directly, and density inversely proportional to absolute temperatures.

The volume per pound of ammonia solutions may be read off directly from Chart 74.

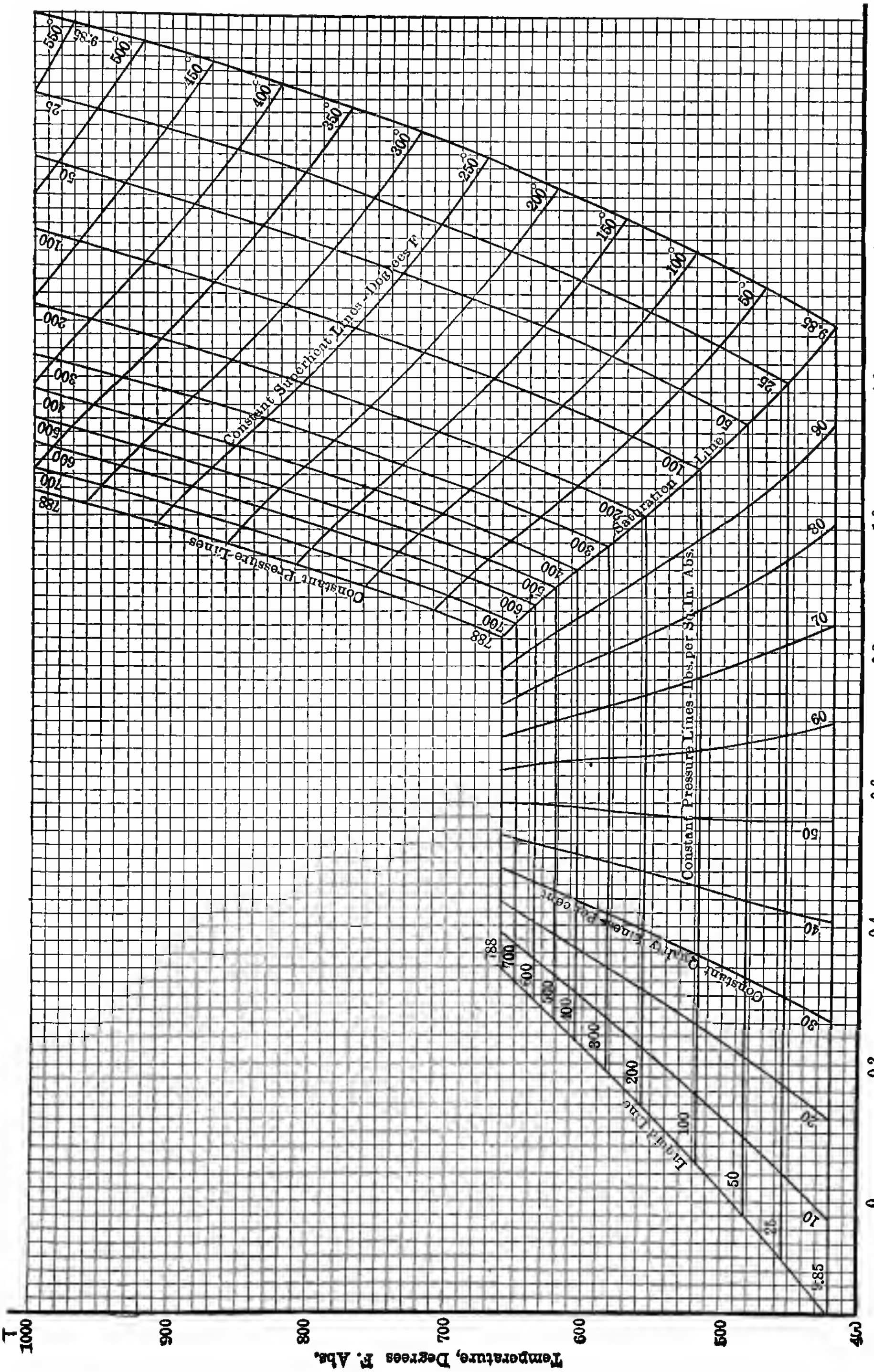


CHART 75.—Temperature Entropy Diagram for Ammonia (NH_3)

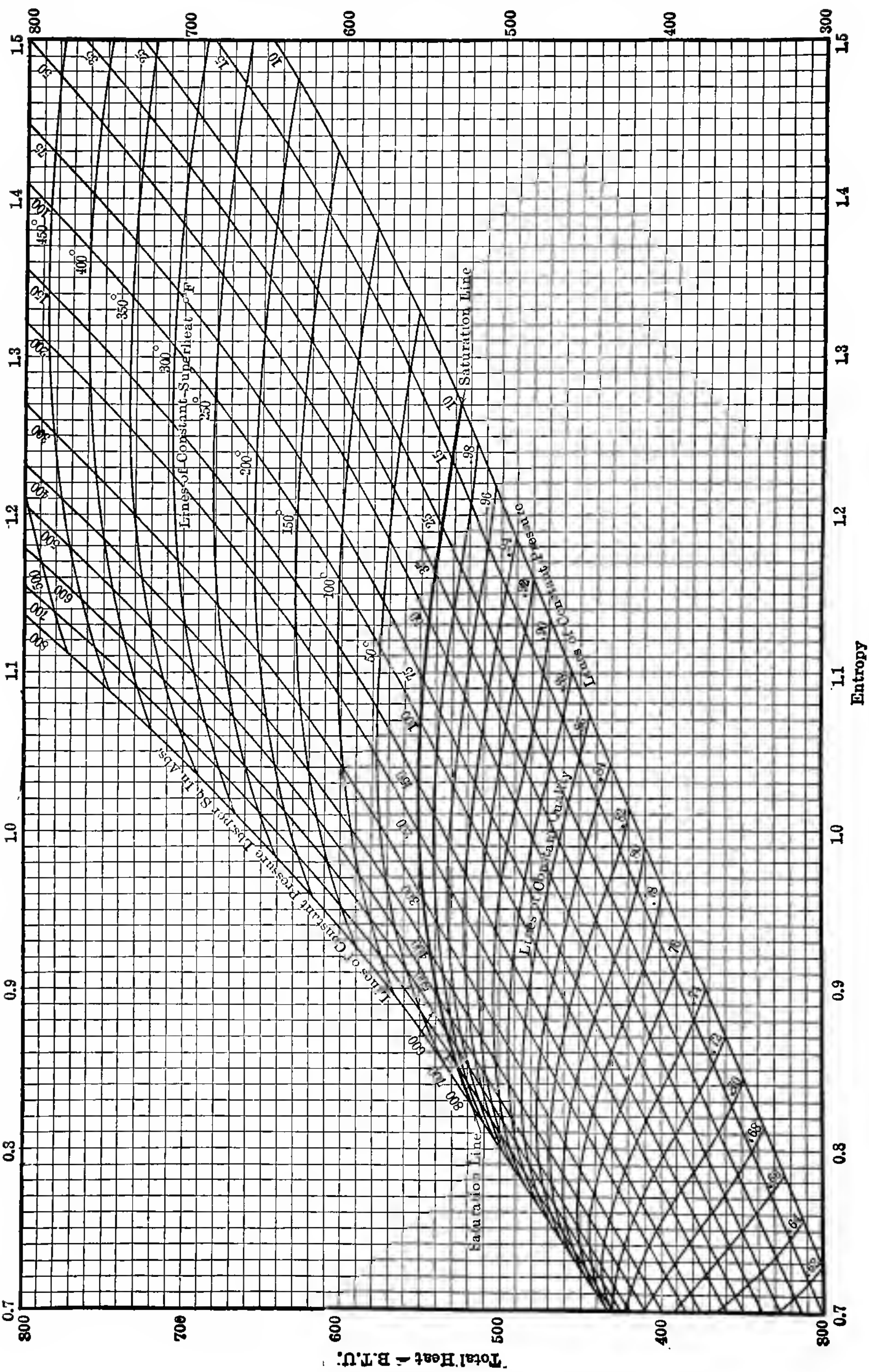


CHART 76.—Mollier Diagram for Ammonia (NH_3)

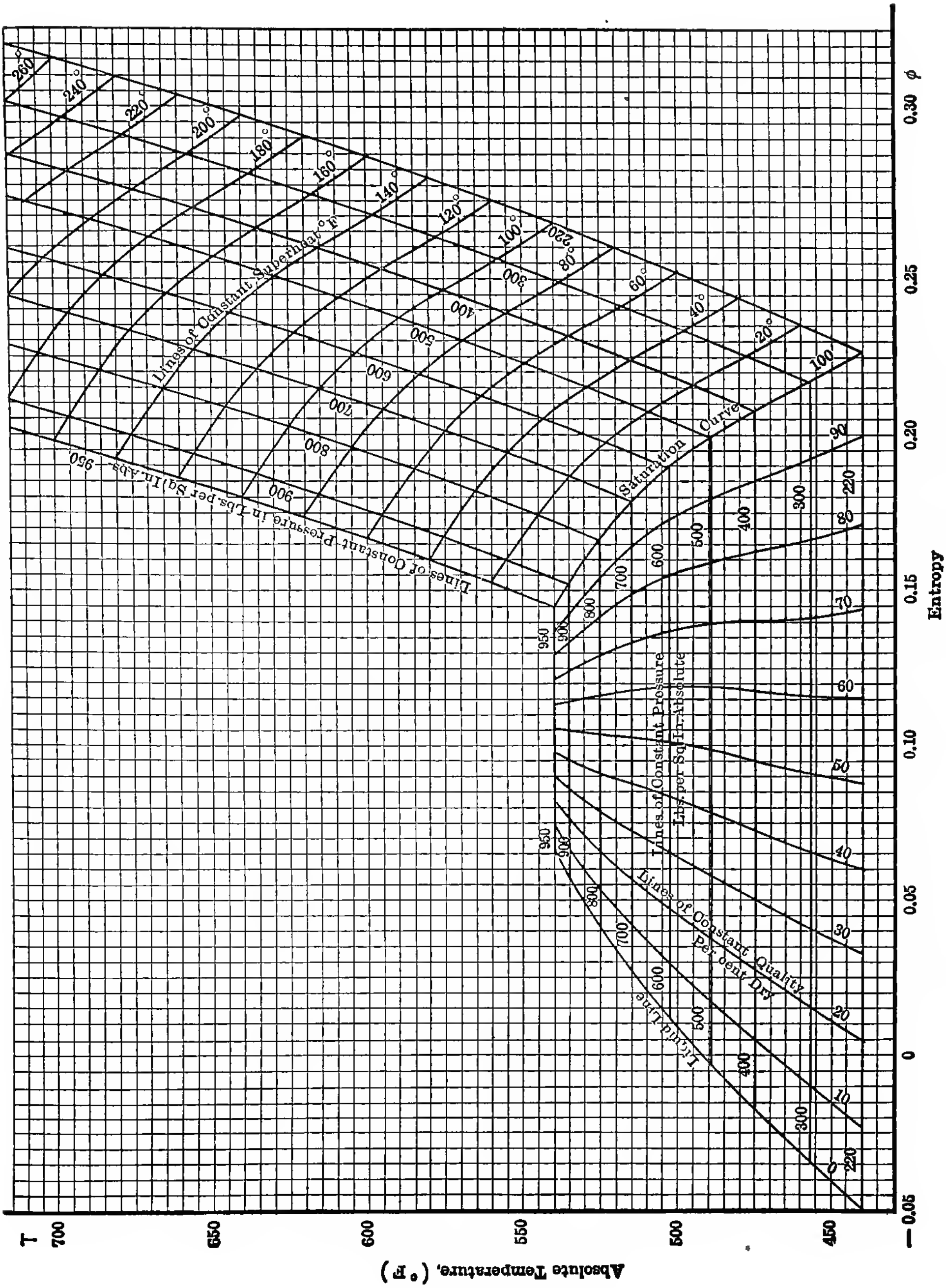
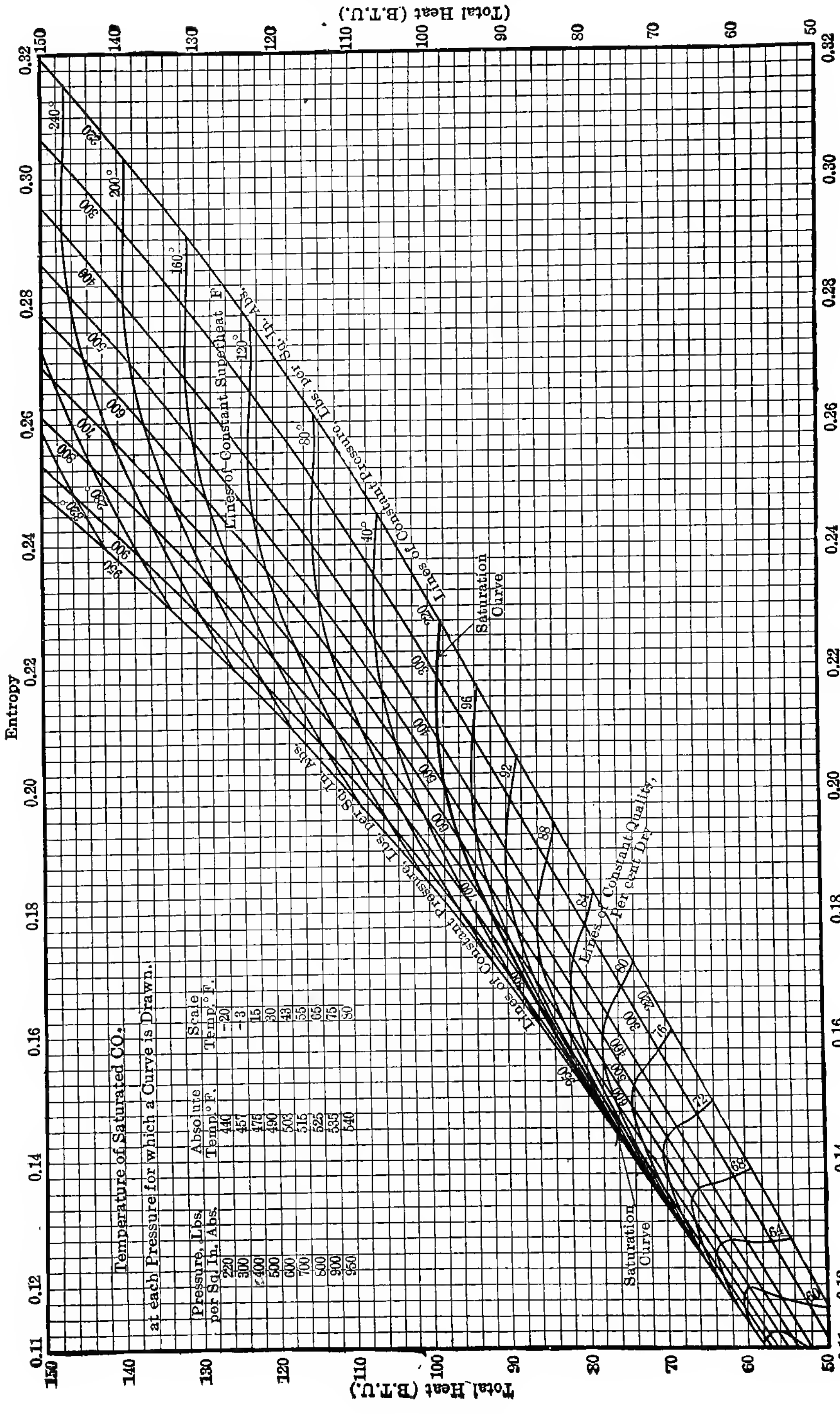


CHART 77.—Temperature Entropy Diagram for Carbon Dioxide (CO_2).



Pressure, Lbs. per Sq. In. Abs.	Absolute Temp. °F.	Scale Temp. °F.
220	440	−20
300	457	−3
400	475	15
500	490	30
600	503	43
700	515	55
800	525	65
900	535	75
950	540	80

CHART 78.—Mollier Diagram for Carbon Dioxide (CO_2).

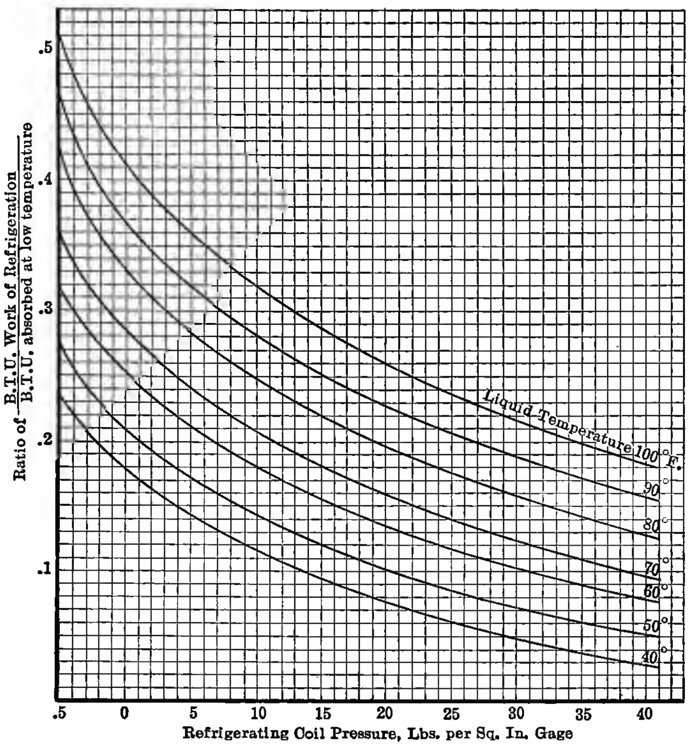


CHART 79.—Work in B.T.U., per B.T.U. Absorbed in Refrigeration, by Ammonia Supplied as Liquid at any Temperature and Vaporizing at any Coil Pressure to Dry Saturated Vapor.

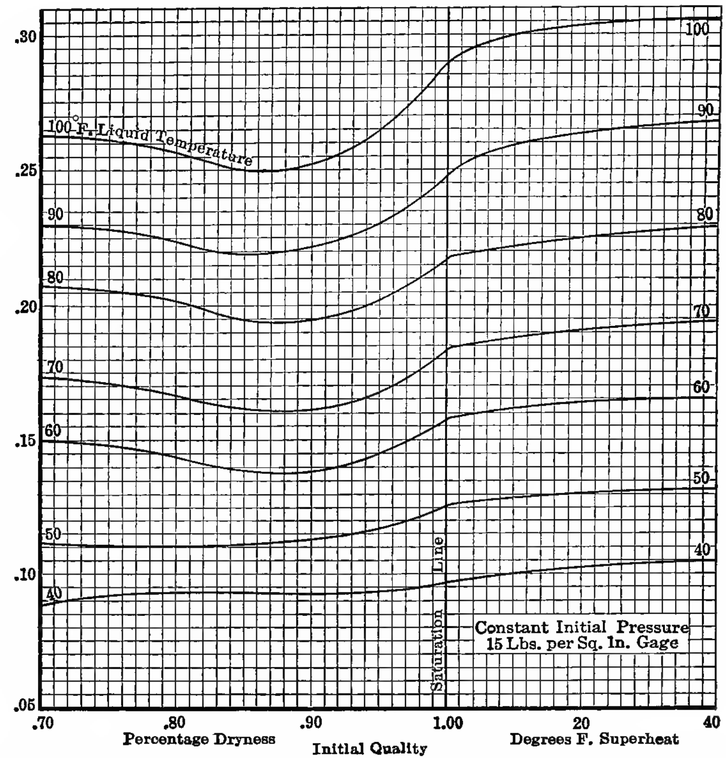


CHART 80.—Work in B.T.U., per B.T.U. Absorbed in Refrigeration, by Ammonia Supplied as Liquid at any Temperature and Vaporizing to any Quality or Superheat at 15 Pounds per Square Inch Gage.

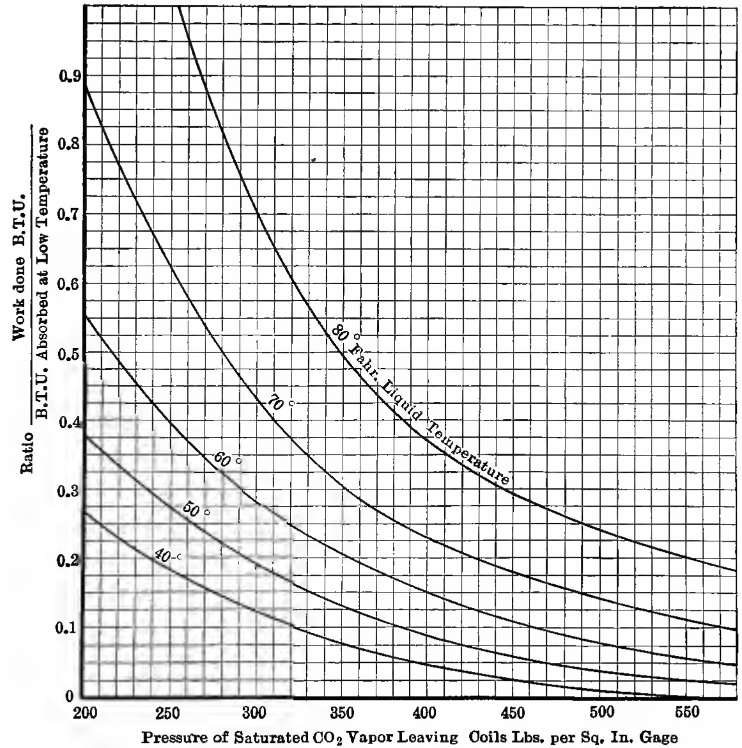


CHART 81.—Work in B.T.U., per B.T.U. Absorbed in Refrigeration, by Carbon Dioxide Supplied as Liquid at any Temperature and Vaporizing at any Coil Pressure to Dry Saturated Vapor.

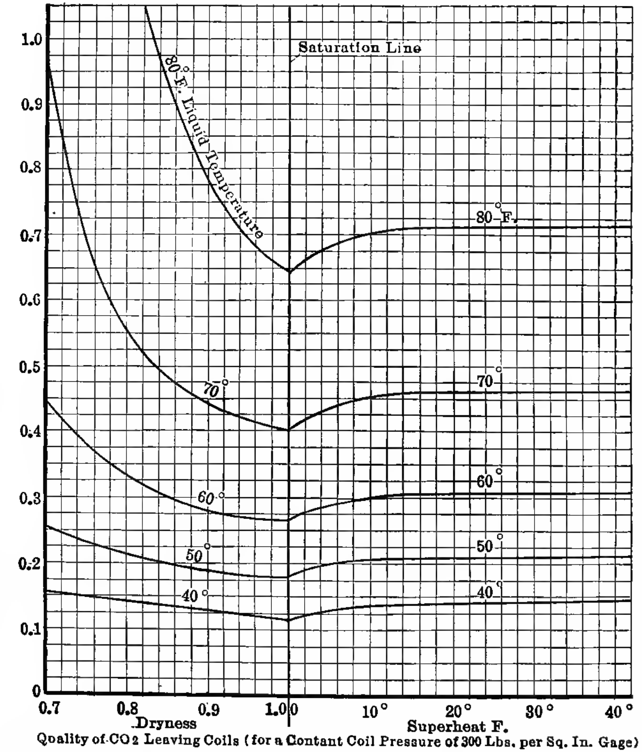


CHART 82.—Work in B.T.U., per B.T.U. Absorbed in Refrigeration, by Carbon Dioxide Supplied as Liquid at any Temperature and Vaporizing to any Quality or Superheat at 300 Pounds per Square Inch Gage.

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